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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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LIST OF STARS MARKED DOUBLE BY ARGELANDER, AND NOT RECORDED BY PREVIOUS OBSERVERS

BY T. E. ESPIN

THE stars marked "Double" in Argelander's "Mittlere Oerter von 33,811 Sternen," *Bonn Observations*, Vol. VI., seem to have generally escaped notice. I have examined the whole of the stars so marked, and after eliminating those that had been observed previous to Argelander's observations, there remain 53, several of which have been rediscovered by modern observers. The following list contains their places brought up to 1880, and his notes and the date of observation.

The abbreviations used by him are :—

Pr. = *precedens*	Dpl. = *duplex*
Seq. = *sequens*	Com. = *comes*
B. = *Borealis*	Cl. = *classis*
A. = *Australis*.	

In the notes which follow the list will be found the differences in R. A. and Decl. when both stars were observed, and in the case of Nos. 14 and 48 the position and distance derived from them. Where a star has been rediscovered by a modern observer reference is made to the fact in the notes and an asterisk placed against the number in column 1.

List of Stars Marked Double by Argelander

No.	B. D.	R. A. 1880		Decl.		Argelander's Note	Date
	°	h	m	°	′		1800
1	+ 0·93	0	32·1	+ 0	51	9·3, III Cl. 9·5 A. Pr.	56·76
2	− 1·82		34·4	− 1	3	9·5, 9·5.	53·92
3	+42·263	1	8·8	+42	17	9·4, III Cl. Com. 9·5.	60·86
4	+48·431		19·6	+48	31	9·3, II Cl.	60·87
5*	+45·464		44·3	+45	13	9·0, 9·0 Seq. 0s·00, 16″ A.	61·97
						8·5, 9·0 Seq. 0s·05, 15″ A.	62·07
6	+26·343		54·7	+26	56	9·5, Dpl.	58·83
7	+51·568	2	17·1	+51	50	8.8, III Cl. B. Seq. Com. 9·1.	61·04
8	+44·583		42·4	+44	59	9·5, 10 Seq. A.	59·86
9	+43·705	3	16·6	+43	51	9·0, 10 Pr. 1s, 0′·4 A.	59·89
10	+45·779		24·4	+45	9	9·1, 9·5 Seq. 0s·42, 0′·4 A.	60·06
11	+60·728		31·1	+60	16	8·8, 8·9, III Cl.	60·07
12*	+27·609		50·9	+27	37	9·3, 9·3, 10″.	57·86
13	+79·157	4	38·9	+79	56	9·3, 9·4, 8″ A.	61·08
14*	+36·1276	5	44·3	+36	16	8·8, 9·4, 10″.	65·13
15	+41·1289		44·6	+41	25	9·0, 9·5 Seq. 1s − 1s·5, 0′·1 A (+41″·1290).	60·14
16	+42·1429		44·9	+42	47	9·3, II Cl., 9·3 Seq., 0s·62, 1″ B.	60·16
17	+10·939		50·5	+10	13	8·8, 9·0.	62·07
18	+10·1277	6	41·9	+10	17	9·3, 9·4, III Cl.	57·18
19	− 1·1600	7	7·0	− 1	29	9·5, 9·7, 10″.	55·21
20	− 1·1624		10·1	− 2	3	9·3, 9·4 Pr. 0s·32, 0′·2 B.	63·07
21	+ 5·1701		26·3	+ 5	56	9·3, 9·4, III Cl.	57·21
22	+ 4·1934	8	7·4	+ 4	29	9·2, 9·3 Pr. 1s·96, 0′·5 B.	65·12
23	+45·1618		33·2	+45	22	9·3, IV Cl. Com. 9·6.	60·16
24*	+39·2143		35·4	+39	14	8·2, 8·5, I Cl. (3 observations).	61·28
25*	+50·1588		46·1	+50	21	9·1, I − II Cl. ?	60·15
26*	−16·2644		51·3	−16	58	7·7, 7·9, P. 180°, D. = 3″(6 observations).	53·28
27	+10·2228	10	52·5	+ 9	53	9·6, 9·6.	56·23
28	.....	11	17·4	−23	3	7·5, Dpl. (3 observations).	52 —
29	− 1·3150	16	7·6	− 1	29	9·2, III Cl.	55·38
30	+43·2598		19·5	+43	8	9·5. 9·6, Pr. 5s, 0′·2 A.	60·46
31	+47·2373		39·6	+47	48	9·4, IV Cl.	60·44
32	−19·4528	17	0·4	−19	2	8·0 Dpl.	53·37
33	+17·3341		43·5	+17	30	9·3, IV Cl.	56·44
34*	+53·2043	18	8·5	+53	28	9·3, III Cl. B. Seq.	60·54
35*	+51·2372		20·9	+51	36	8·7, 8·7, I Cl. D. = 3″ (2 observations).	62·02
36	−15·5063		35·1	−15	58	8·0, Dpl. P.	53·44
37	+44·3069	19	5·5	+44	51	9·5, IV Cl. A. Seq.	59·35
38	+31·3576		19·5	+31	43	9·4, IV Cl. Com. 9 7.	58·62
39	+28·3389		29·2	+28	40	9·4, III Cl. 9·4 Pr. D. = 13″.	58·63
40	+46·2777		42·1	+46	5	8·9, 9·6 Pr. 2s, 0′·4 B.	59·61
41	+49·3131		50·1	+49	20	9·5, 9·7 Pr. 2s.	59·36
42	+36·3796		54·5	+36	37	9·4, IV Cl. 9·5 Pr. 1s, 0′·4 A.	58·77
43	+43·3473	20	0·9	+43	45	9·3, 9·5 Seq. 2s, 0′·6 A.	59·72
44	+21·4146		13·1	+21	15	9·6, IV Cl.	57·64
45	+30·4010		18·6	+30	30	8·4, 9·1, IV Cl.	62·77
46	+41·3746		21·4	+41	31	9·3, 9·7 Pr. B.	59·63
47*	+32·3936		42·1	+32	25	8·7, 9·3.	57·80
48	+ 1·4366		43·0	+ 1	58	9·5, IV Cl., Seq. 9·7.	54·66
49	+42·4219	21	44·3	+42	8	9·3, IV Cl., 9·6 Pr. 0s·5, 0·3 B.	59·03
50	+ 1·4575		57·9	+ 1	22	9·5, 9·5 D. = 10″.	53·82
51	+ 2·4529	22	30·0	+ 2	57	9·5, III Cl., 9·5 Pr. 1s·00, 10″ A.	54·74
52	+45·3994		31·2	+45	25	9·5, IV Cl., 9·7 Pr. A. (2 observations).	59·36
53*	+60·2650	23	52·1	+60	22	8·7 Dpl. A. Seq.	61·90

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NOTES

5 A. G. 24.
11 Argelander $\Delta\alpha$ 1s·01 $\Delta\delta$ 5″·0.
Ast. Gesel. " 0·68 " 4·5.
12 A. G. 75.
14 A. G. 101. Argelander's places give P. 78°·1, D. 10″·13.
17 $\Delta\alpha$ − 2s·19 $\Delta\delta$ +15″·0.
18 $\Delta\alpha$ +0s·89 $\Delta\delta$ − 6″·2.
21 $\Delta\alpha$ +0s·82 $\Delta\delta$ − 15″·0.
24 β 209.
25 A. G. 158.
26 β 210.
34 A. G. 217.
35 Espin 187.
45 $\Delta\alpha$ − 0s·08 $\Delta\delta$ +21″·0.
47 A. G. 266. Argelander's places give P. 270°·0, D. 12″·81.
53 De. 28.

NOTE.—Argelander's words after the *class* of double stars seem frequently to refer not to the position of the companion, but to which of the two stars was observed with the transit instrument. Thus in No. 37 "A. seq." refers to the fact that the south following star was the one whose place was taken, the companion being therefore north preceding.

THE FORTY-NINTH PARALLEL

By Otto Klotz

WE shall begin by quoting two paragraphs from the Romanes Lecture on "Frontiers," delivered by Lord Curzon at Oxford on November 2, 1907.

"I wonder, indeed, if my hearers at all appreciate the part that Frontiers are playing in the everyday history and policy of the British Empire. Time was when England had no Frontier but the ocean. We have now by far the greatest extent of territorial Frontier of any dominion in the globe. In North America we have a Land Frontier of more than 3,000 miles with the United States. In India we have Frontiers nearly 6,000 miles long with Persia, Russia, Afghanistan, Tibet, China, Siam and France. In Africa we have Frontiers considerably over 12,000 miles in length with France, Germany, Italy, Portugal and the Congo State, not to mention our Frontiers with native states and tribes. These Frontiers have to be settled, demarcated, and then maintained. We commonly speak of Great Britain as the greatest sea-power, forgetting that she is also the greatest land-power in the Universe."

In discussing the various classes of frontiers, (1) the natural frontiers—the sea, deserts, mountains and rivers, and (2) the artificial frontiers, Lord Curzon says of the commoner forms of the latter:

"These are three in number: (1) what may be described as the pure astronomical Frontier, following a parallel of latitude or a meridian of longitude; (2) a mathematical line connecting two points, the astronomical co-ordinates of which are specified; and (3) a Frontier defined by reference to some existing, and, as a rule, artificial feature or condition. Their common characteristic is that they are, as a rule, adopted for purposes of political convenience, that they are indifferent to physical or ethnological features, and that they are applied in new countries where the rights of communities or tribes have not been stereotyped, and where it is possible to deal in a rough and ready manner with unexplored and often uninhabited tracts. They are rarely found in Europe, or even in Asia, where either long settlement or conflict has, as a rule, resulted in boundaries of another type.

"(1) The best known illustration of the astronomical line is the Frontier between Canada and the United States, which from the Lake of the Woods follows the 49th parallel of latitude to the Pacific coast, a distance of 1,800 miles [1,270,—

O. K.] This line well illustrates both the strength and the weakness of the system. As a conventional line through unknown territories it has answered its purpose. But its demarcation on the spot was so laborious and protracted that, fifty years after the conclusion of the Treaty which created it, the joint surveyors were still at work, clearing a strip 100 yards wide through the primeval forest, and ornamenting it with iron pillars and cairns, at a cost to both countries which was enormous. Similar lines have been employed to define the boundaries of Canada and Alaska, to separate many of the Australian Colonies from each other, to determine European Spheres of Influence or Protectorates in Africa, and, quite recently, to define the Russian and Japanese shares of the island of Saghalin. Such lines are very tempting to diplomatists, who in the happy irresponsibility of their office-chairs think nothing of intersecting rivers, lakes and mountains, or of severing communities and tribes. But even in the most favorable circumstances they require an arduous triangulation on the spot, and until surveyed, located, and marked out, have no local or topographical value."

The above-quoted two paragraphs contain very interesting statements, and the second one is particularly pertinent to the subject of this paper.

By Article II. of the Convention of October 20, 1818,

"It is agreed that a line drawn from the most northwesterly point of the Lake of the Woods, along the forty-ninth parallel of north latitude, or, if the said point shall not be in the forty-ninth parallel of north latitude, then that a line drawn from the said point due north or south as the case may be, until the said line shall intersect the said parallel of north latitude, and from the point of such intersection due west along and with the said parallel shall be the line of demarcation between the territories of the United States, and those of His Britannic Majesty, and that the said line shall form the northern boundary of the said territories of the United States, and the southern boundary of the territories of His Britannic Majesty, from the Lake of the Woods to the Stony Mountains" (Rocky Mountains).

This line is 860 miles long.

In passing it may be remarked that in the above description is contained the explanation why Minnesota projects into Canada at the North West Angle,—because the North West Angle happened to lie north of the 49th parallel; a connection had to be made between a physical feature and a fixed astronomic line.

The remaining part of the international boundary along the 49th parallel is described in Article I. of the Treaty concluded at Washington on June 15, 1846, as follows: From the point on the

"forty-ninth parallel of north latitude, where the boundary laid down in existing

treaties and conventions between the United States and Great Britain terminates, the line of boundary between the territories of the United States and those of Her Britannic Majesty shall be continued westward, along the said forty-ninth parallel of north latitude, to the middle of the channel which separates the continent from Vancouver's Island, and thence southerly through the middle of the said channel, and of Fuca's Straits, to the Pacific Ocean."

This line is 410 miles long, making a total in round numbers of 1,270 miles along the 49th parallel.

The part from the Lake of the Woods to the Rocky Mountains was surveyed and marked by monuments by an international commission during the years 1872–3–4, while on the remaining part to the Pacific, an international commission determined individual points on the 49th parallel and erected some monuments during 1857 to 1861, but the boundary line was not then wholly surveyed owing to the mountainous character of the country; this, however, has recently been effected by another international commission, of which Dr. W. F. King, C.M.G., was the British representative, and Dr. O. H. Tittmann the representative for the United States.

Let us dwell for a moment on the meaning of the word latitude and on the method of determining it. Latitude may be defined as the elevation of the Pole, or its height in degrees above the horizon, and the method is to measure with a suitable instrument from the horizon the angle to the Pole. Next let us inquire what is the horizon from which we measure, and the answer is, —the plane at right angles to the vertical; and, finally, we ask what is the direction of the vertical? the answer is,—it is the integrated result of the attraction of the individual particles composing the mass of the earth, and hence the position is affected by the relative distribution of them. We may therefore say that the unsymmetrical distribution of the particles, whether on the surface as mountains or valleys, or in the thin crust, is the cause of the "deflection of the plumb line" or vertical from its theoretical position, and latitude observations will be affected by just this amount of deflection. In some instances we are quite prepared to find local deflections of the plumb line, for example, when observations are taken on the plains at a point near

a more or less isolated upheaval, as the Three Buttes or Sweet Grass Hills in Montana, just south of the International Boundary. These hills, as we shall see later, pulled the 49th parallel out of its theoretical position about 800 feet. On the other hand, large deflections show themselves without any visible reason or cause as evolves from numerous observations and their geodetic connection. From such it must be concluded that there exists beneath the surface of the earth matter of abnormal density.

All observations for the determination of positions upon the earth depend upon the direction of the vertical. Latitude and longitude observations, the surveyor's and engineer's operations, all have their zero of reckoning in the center of the level bubble, and any displacement of the latter, which is equivalent to the displacement of the plumb-line, affects the results, and will show discordances when widely separated observations are geodetically connected.

It may be stated that a delicate level used for latitude work, reading to a second of arc, has usually a radius of about 1,700 feet, or nearly a third of a mile, for the curve ground on its inner upper surface.

When a boundary is defined by a parallel of latitude, the question invariably arises, in the demarcation of it, whether the astronomic or mean parallel is to be adopted. The astronomic parallel is that line on the surface of the earth on which direct observations for latitude give the same elevation of the Pole; geometrically, for the spheroid or ellipsoid of revolution, it is the angle made by the normal to the surface of the earth with the major axis, or it is the angle made by the tangent cone with the minor axis produced. Principally owing to the local deflection of the plumb line, points astronomically determined in latitude will not "close," that is, the line projected or determined as a parallel from one station will not meet the next point or astronomic station.

That line with reference to which the sum of the discrepancies north is equal to the sum of those south is the mean parallel.

However, as the latter can only be determined *after* the location and connection of the astronomic points, entailing revision of the whole work, and besides the difficulty of re-establishing points on the mean parallel in case of loss or disappearance of monuments and marks, it has generally been decided to adhere to the simpler and more readily established astronomic parallel. All such parallels traced upon the earth are irregular curves.

On the line from the Lake of the Woods to the Rocky Mountains, 860 miles, 40 astronomic stations were established, and 388 monuments erected.

After due consideration, the commissioners for this part of the parallel agreed upon the astronomic parallel. The recommendation for this, by the chief astronomers of the commission, was based on the following grounds:—1st: That the portion of the parallel of 49° included within the operations of the commission, being only about one-twentieth of the entire circle of latitude, was not sufficient to fix, with any mathematical accuracy, the true position of the mean line of 49°, and that, therefore, if such a parallel were described, depending on the mean of the astronomic stations, no known point of the boundary would be in latitude 49°; 2nd: That as the amplitude of the arcs, included between the mean and the astronomical parallels, would in many cases be very considerable, grave errors and complications might arise in the subsequent re-survey of any lost portion of the boundary; 3rd: That the definition of a mean line would involve a re-adjustment of the whole boundary, after the first careful survey should have been completed, and consequently a very considerable increase of expense, without any practical benefit accruing; 4th: That for every purpose, except that of geodetic computation, a parallel of points determined astronomically (instrumental errors aside), is a true parallel of latitude, and, therefore, fulfils the stipulations of the treaty under which the joint commission was organized.

Accordingly, astronomic positions were determined at approximate intervals of twenty miles. These stations were connected by tracing upon the ground tangents or the prime

vertical circles at each successive point. From these tangents, checked and corrected for errors of azimuth, the calculated offsets to the small circle of latitude were measured at convenient intervals, varying from one to three miles. From the last mentioned offset the relative station error (deflection of plumb line) was found and distributed between the two stations in the ratio of the distances where offsets were taken. From this method it results that the boundary line, as actually traced, is an irregular curve, affected at each astronomical point by instrumental errors and by the local deflection of the plumb line, making the closest probable approximation, at every point, to a true astronomical parallel.

Of the forty astronomical stations on the 49th parallel, four were observed jointly, seventeen by the United States astronomer and nineteen by the British. The mean of the probable errors of the British stations was $\pm''{\cdot}088$ and of the United States $+''{\cdot}05.9$ The average of the probable error is then a little over seven feet.

The greatest difference of station errors is $13''{\cdot}89$ or 1,407 feet, being in a distance of $97\ ^{7}/_{10}$ miles, between the Cypress Hills to the north of the boundary, and the Three Buttes or Sweet Grass Hills near, and to the south of the 49th parallel. The station error of the former is $+\ 5''{\cdot}94$, of the latter $-7''\ 95$, that is, the Three Buttes pulled the 49th parallel 805 feet south, and the Cypress Hills 602 feet north of the mean parallel. The greatest discrepancy between adjacent stations, about twenty miles apart, is $7''{\cdot}28$ or 738 feet, near the Three Buttes.

Looking at the accompanying diagram, in which the upper figure is a representation (much exaggerated) of the relative position of the astronomic and mean parallels, while the lower figure shows the main features of the topography for a distance of about thirty-five miles on each side of the boundary line, the large deflections appear obvious from the topography. From the Lake of the Woods, westward, into the valley of the Red River, the station errors increase, and for a reason which, from our lack of knowledge of the underlying strata, must be conjectural. The escarpment of the Pembina Mountains (elevation would be

a more appropriate term, height 1,695 feet) naturally draws the vertical southward, continuing to do so until the Turtle Mountains (of moderate elevation, 2,550 feet) are reached, which, too, deflect to the south. After entering the Côteau of the Missouri we pass along the southern base of the high ridge, separating the waters flowing into the Gulf of Mexico, from those flowing into Hudson Bay, and find, naturally, a deflection to the north, increasing to a maximum south of the Cypress Hills (3,800 feet). Here the extrusive masses of the Three Buttes produce a violent disturbing effect. When we actually enter the tumultuous Rocky Mountains, with all their varied conditions of composition, of faults and dykes, and our lack of hypsometric maps, we are unable to even make a plausible estimate in which direction the local deflection is to be expected.

It is evident that observations at two places, which are also geodetically connected, can only give the relative deflection of the plumb line.

For the boundary between the Lake of the Woods to the summit of the Rocky Mountains, the Commissioners agreed that the line joining any two adjacent monuments shall be an arc of the parallel. This was to apply, too, in the case of restoring any monument whose position was lost. This agreement differs from that of the boundary commissioners, who had charge, some 17 years previously, of defining the boundary from the Gulf of Georgia to the summit of the Rocky Mountains. They agreed that the connecting line between monuments shall be a straight or direct line, *i.e.*, an arc of a great circle.

Between the extreme east and west points, upon the watershed of the Rocky Mountains, and the eastern shore of the channel which separates the continent of North America from Vancouver Island in west longitude 114° 3′ 34″ and 123° 3′ 53″ respectively, the exact length of the boundary line upon the 49th parallel of north latitude is 409 $^{4}/_{10}$ miles. The position of the parallel was determined by 28 astronomical stations, 11 of which were established by the British Commission, 14 by the American Commission, and 3 were observed by both. Another station was

fixed by the British Commission at Schweltza Lake, but it was at the time rejected on account of the apparently large deflection of the plumb line, though the after experience of the most accurate instrumental observations in that mountainous country, led to the conclusion that the result at Schweltza was quite as trustworthy as any of the others. It is, however, not included in the final determinations.

At the first meeting of the Commissioners at Semiahmoo, August 13, 1858, it was concluded, after discussing plans for determining and marking the line as far as the Cascade Mountains, to be inexpedient at that time, in consequence of the great expense, consumption of time, and the impracticable nature of the country, to mark the whole boundary by cutting a track through the dense forest. It was therefore agreed to ascertain points on the line by the determination of astronomical points at convenient intervals on or near the boundary ; and to mark such astronomical stations or points fixed on the parallel forming the boundary, by cutting a track of not less than 20 feet in width on each side for the distance of half a mile or more, according to circumstance. Further, that the boundary be determined and similarly marked where it crosses streams of any size, permanent trails, or any striking natural features of the country. In the vicinity of settlements, the line was to be cut a greater distance. Bessel's value of the figure of the earth was adopted.

From the two points on the parallel, dependent, respectively, on the Sumass and Schweltza astronomical stations, cuttings were made to connect the points. When the cuttings met, there was found to be a discrepancy of 8″, say about 810 feet ; they were, however, connected, though the line thus defined is obviously not strictly *the* boundary of the treaty. The distance is about 9¼ miles. This relative deflection of the plumb line, 8″, in so short a distance, is the largest on the whole 49th parallel, from the Lake of the Woods to the Pacific. When the cuttings on the parallel from Sumass and the British stations at Semiahmoo met, there was a discrepancy of 114 feet in the twenty miles, and between the United States astronomical station at the east

shore of Semiahmoo Bay, and the British one five miles east thereof, a discrepancy on the parallel of nearly nine feet was found an error quite within the error of observation.

The only other cutting on the whole boundary line west of the Rocky Mountains, connecting adjacent astronomic stations, is between the Similkameen and the Columbia Rivers, a distance of 96 miles. The stations there in order eastward are: Similkameen (U. S.); Lake Osoyoos (Br.); 1st Crossing Newhoilapitkw (U. S.); 2nd Crossing Inshwointum (Br.); 3rd Crossing Statapoosten (U. S.); and on the Columbia (Br. and U. S.) From the point on the parallel at Lake Osoyoos, a line was run east and west 30 1/5 miles, connecting with similar points at Similkameen and at the 1st Crossing. The line was found to strike 509 feet north of the former point and north of the latter 364 feet, showing a marked deflection of the plumb line. When, similarly, an east and west line was run from a point on the parallel at Inshwointum, it was found to be south 300 feet of the point on the parallel at the 1st Crossing, and 180 feet north of the point at Statapoosten.

This shows, therefore, a discrepancy between the latitude at Lake Osoyoos (Br.) and Statapoosten (U. S.) of 844 feet, due to local attraction or difference of local attraction. After verifying the accuracy of the latitude observations, it was decided to adopt the mean parallel, based on the differences found, between Similkameen and Statapoosten—a distance of 71 miles. This is the only part of the whole boundary line between the Lake of the Woods and the Gulf of Georgia, where a mean parallel has been adopted for the boundary, instead of the astronomic parallel. These seventy-one miles were re-cut on the mean parallel. From the extremity of the mean parallel at Statapoosten, an east line was run to the Columbia, where a difference of 112 feet was found between the mean of the British and United States latitude determinations there and the mean parallel. The line (for final boundary) was thereupon deflected from Statapoosten so as to strike the above mean Columbia position of the 49th parallel.

As already stated, the Boundary Commissioners had agreed to understand the boundary laid out by them, to consist of a series of straight lines between the successively marked points, without regard to the distances between these two points or the curve of the parallel in the longer intervals. This they did upon the consideration that it was of the greatest importance that nothing should be left for future discussion of settlement, and that the operations should be final and conclusive. It may be stated that opposite the center of a chord of 25 miles in length, the departure from the 49th parallel would be about 40 yards, and of 12 miles, 9 yards. Both these departures are probably far smaller than the deflection of the plumb line, at the governing astronomical stations.

We have, therefore, in the actual boundary line of British Columbia, a deviation from the 49th parallel, as given in the treaty of June 15th, 1846, in so far, that the straight lines replace the curve of the parallel between all the stations, and, furthermore, that between Similkameen and Statapoosten, the mean parallel was adopted instead of the astronomically determined points.

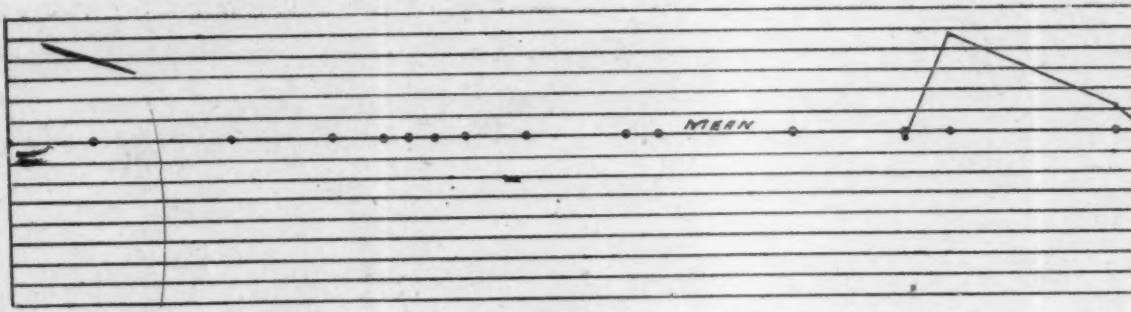
We have followed now the 49th parallel for 1,270 miles, about one-thirteenth of its circumference, and it has disclosed to us some of its vagaries as manifested in the latitude component of the deflection of the plumb line. This boundary line is the longest astronomic one on the earth, the nearest approach to it being the meridian separating West Australia from North and South Australia.

In connection with the deviation of the plumb line it may be interesting to quote a few extracts from Dr. J. B. Messerschmitt's report in the ninth volume of *Das Schweizerische Dreiecknetz, herausgegeben von der Schweizerischen geodätischen Kommission.*

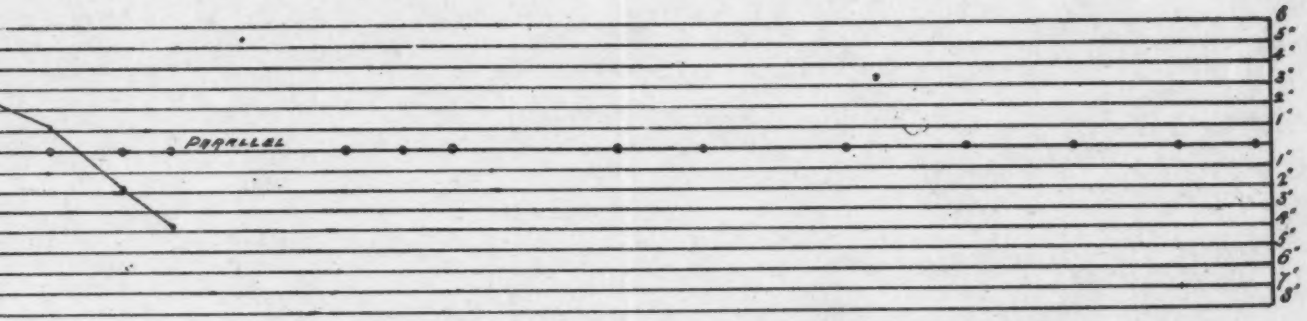
"If we connect all points having the same deflection in latitude we will obtain lines fairly parallel to the direction of the mountains They show plainly and markedly the relative attractions of the Alps and the Jura, as is to be expected, the influence of the former extending close to the foot of the latter. . . . . In the neighborhood of Zurich the deflection is small while at Lucerne it is 6″; at Zugerberg the deflection in latitude is nearly 9″; while at Rigi, which is only 36

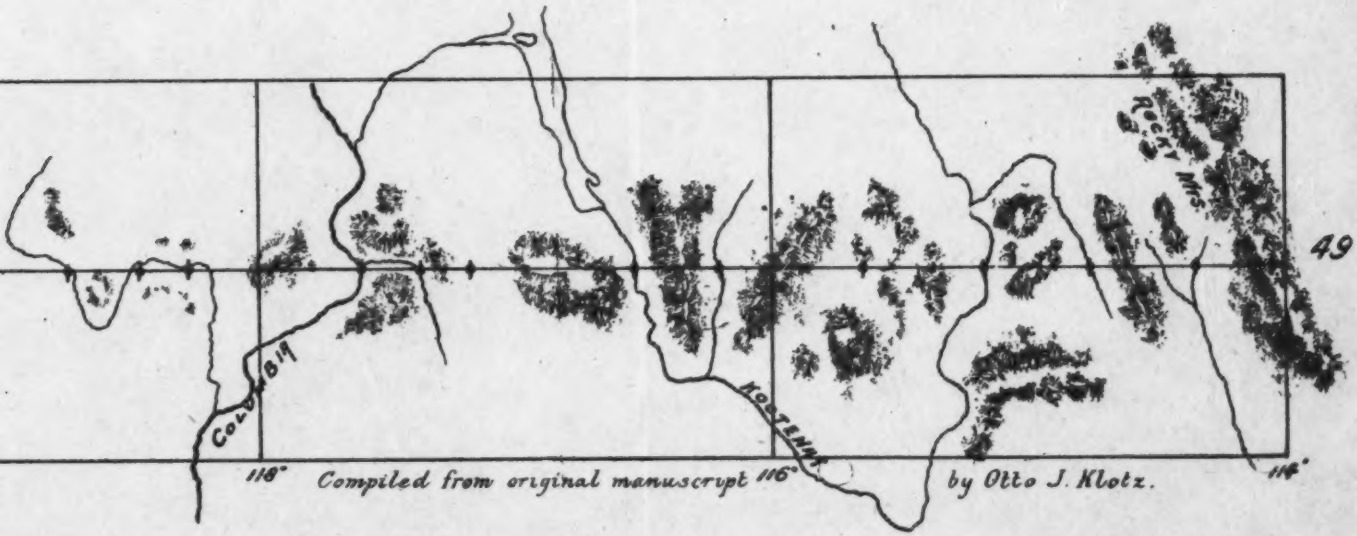
km. to the south, it is between 17″ and 18″. As we approach the center of the Alps the deflection decreases, being about zero a little to the south of St. Gotthard. Similar conditions obtain on the south side of the Alps. While at Biasca the deflection is small, it reaches 17″ at Lugano. . . . . These conditions are not, however, confined to Switzerland, but apply equally to the whole Alpine region of Austria, Italy and France, where, however, the data are not as complete as for Switzerland. The direction of the plumb line is always perpendicular to the mountains; the deflection increases rapidly as the mountains are approached, and values as high as 30″ have been obtained, although in Switzerland the maximum is about 20″. If we compare the deflection on both sides of the Alps we obtain a difference of 50″ in a distance of 100 km. Remembering that 1″ in latitude is equivalent to 31 m. linear measure, it will be seen that the distance between two points, one north and the other south of the Alps, determined astronomically will differ from that obtained geodetically by over 1 per cent. That is, in about 62 miles the distances will differ by 5,000 feet, or nearly a mile."

The same law or force which causes the deflection of the plumb line, determines the length of the seconds pendulum, preserves the planets in their orbits, and maintains the stability of the universe—is the law of gravitation. Our earth furnishes us with many interesting problems, and the very discordances observed—apparent though they are—tend to lead us on to unraveling the mysteries and intricacies of nature, and to unfolding the unity and harmony of the cosmos.

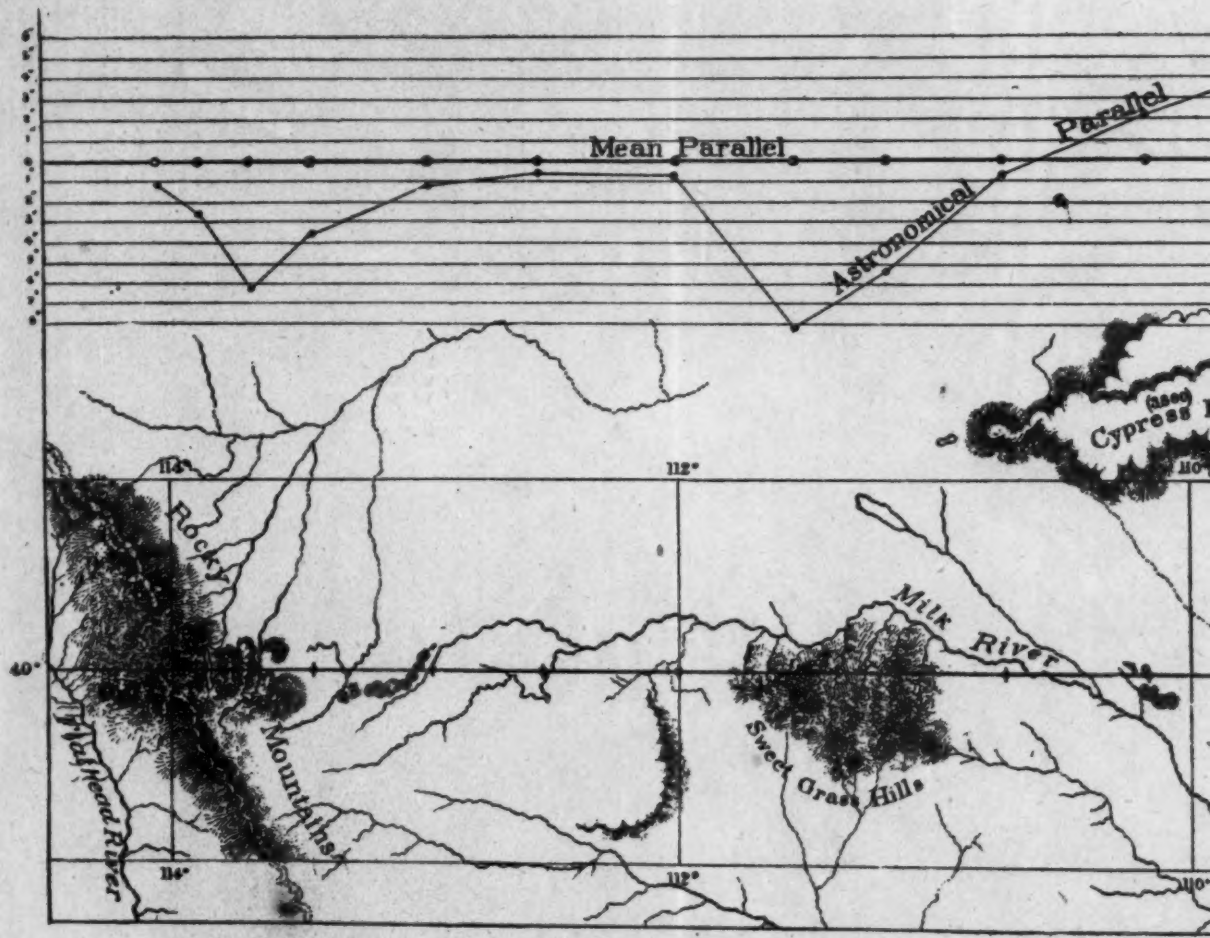

MEAN

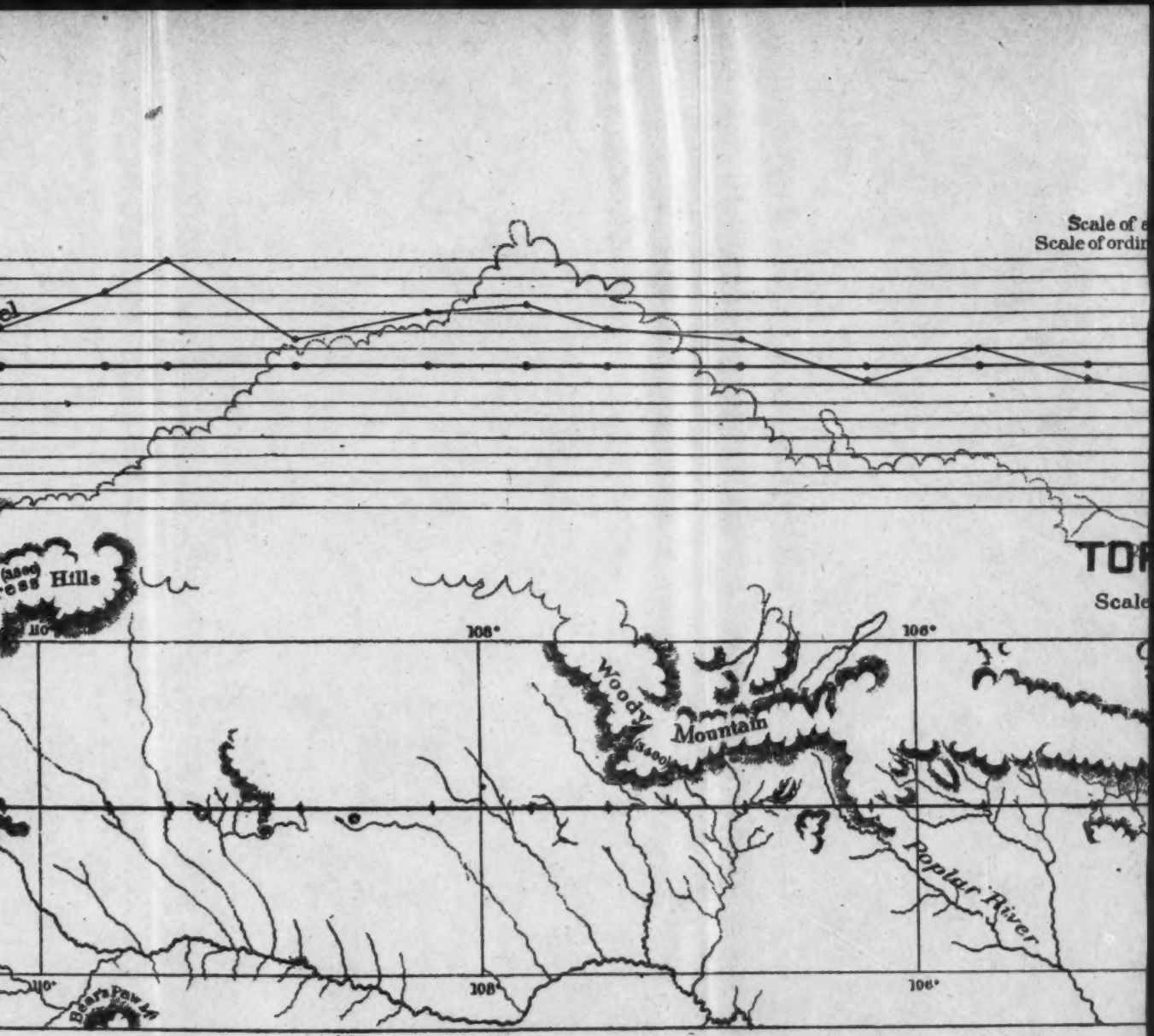
GULF OF GEORGIA
FRASER
SIMILKAMEEN
10,700
123°
122°
120°



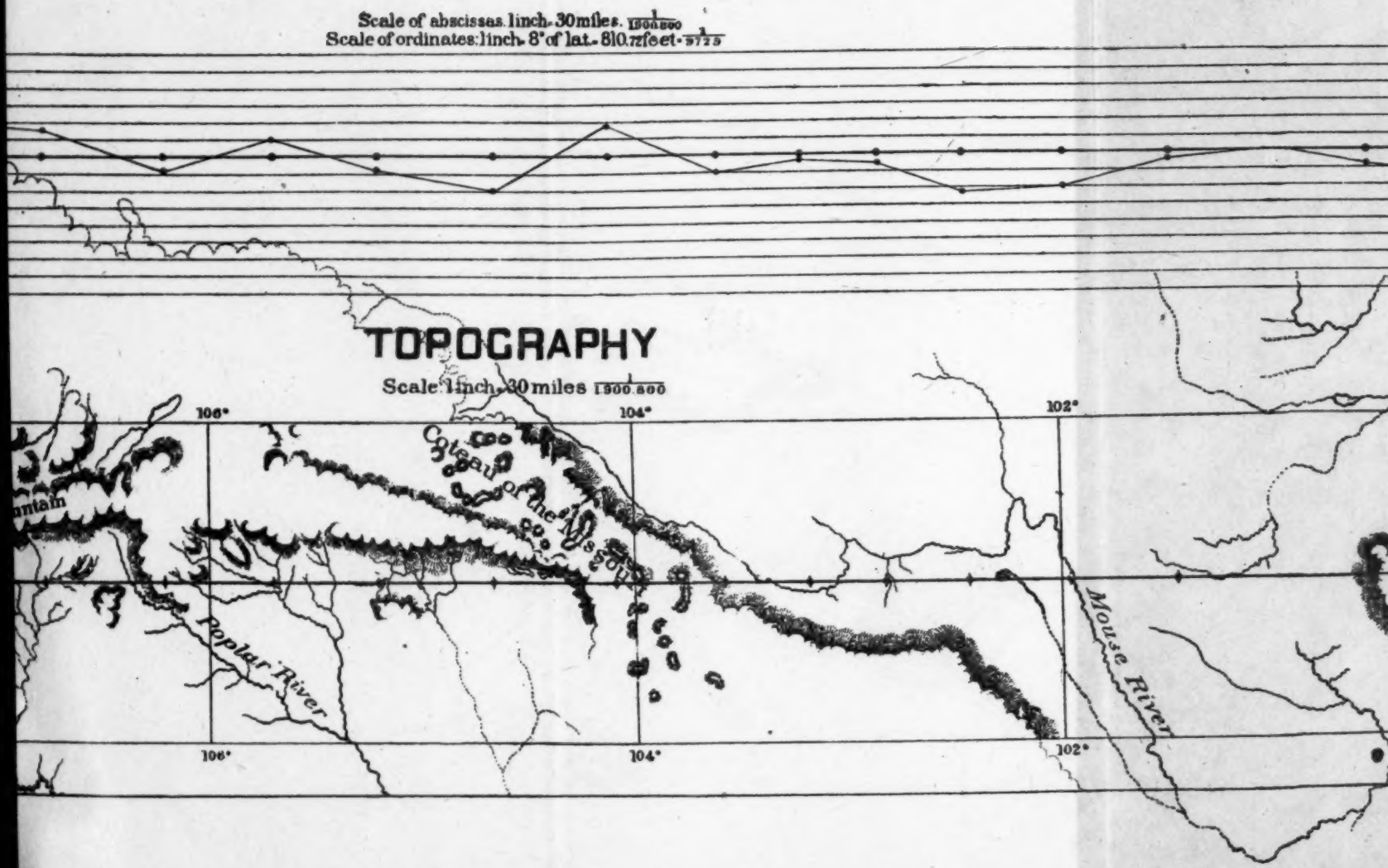


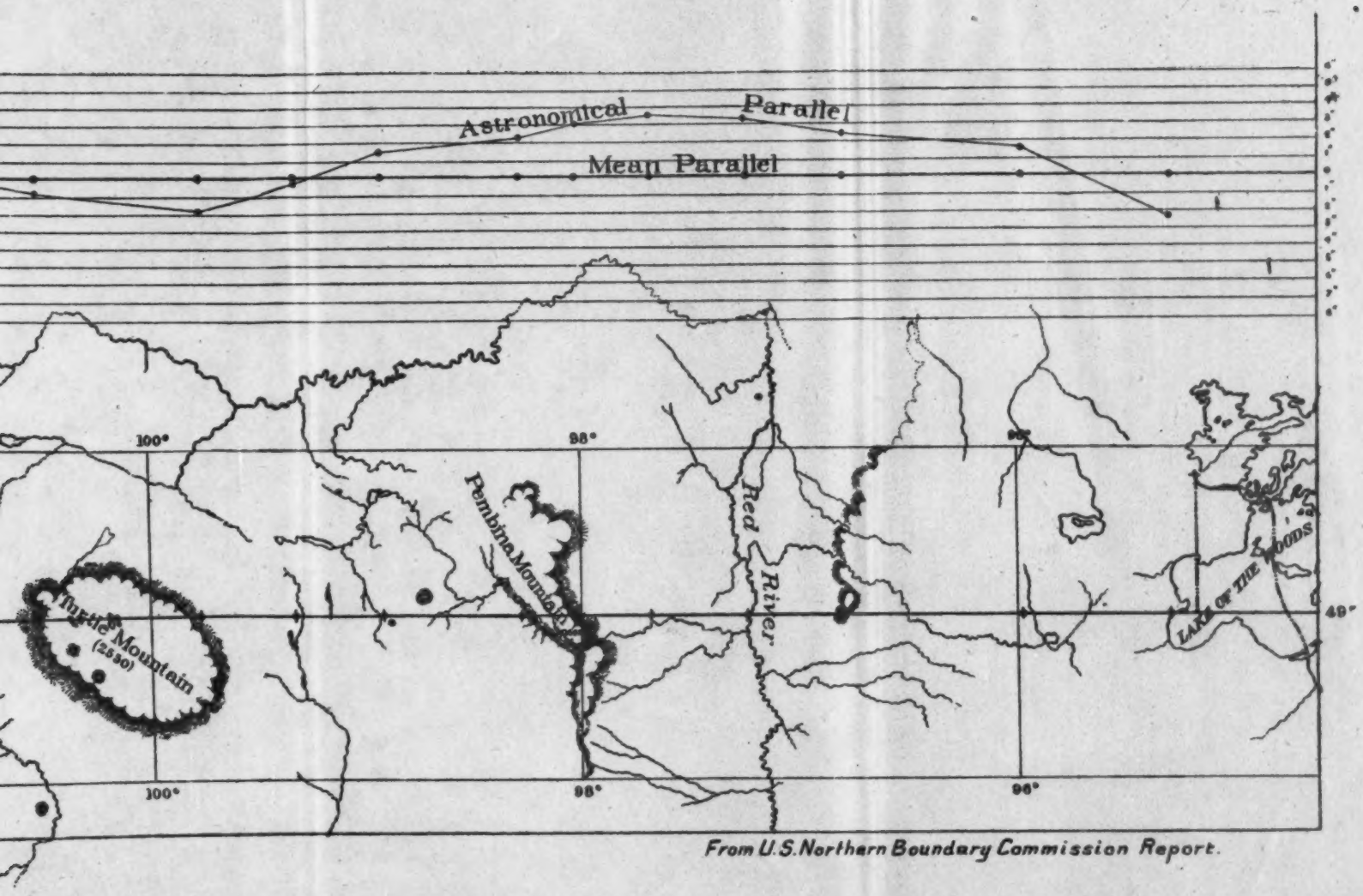
Compiled from original manuscript by Otto J. Klotz.


Mean Parallel
Astronomical Parallel
Cypress
114°
112°
110°
40°
Rocky
Mountains
Milk River
Sweet Grass Hills
Waterhead River


Scale of
Scale of ordi
Hills
110°
108°
106°
Woody
Mountain
Poplar River
Bears Paw M

Scale of abscissas. 1 inch = 30 miles. 1/1,900,800
Scale of ordinates: 1 inch = 8° of lat. = 810.7 feet. 1/5729





From U.S. Northern Boundary Commission Report.

THE EFFECT OF ATMOSPHERIC PRESSURE UPON THE EARTH'S SURFACE

By F. Napier Denison

THE object of the following notes is to bring before the members of the Royal Astronomical Society of Canada all account of certain earth movements observed on the Pacific Coast, which it is hoped may tend to explain the cause of some terrestrial phenomena not fully understood and also lead to a further investigation of the subject.

In the autumn of 1898 a Milne Horizontal Pendulum was installed at Victoria, B. C., in connection with our Meteorological Service, and from then to the present time continuous photographic records have been obtained from it.

Apart from the shorter period undulations as earthquakes, tremors, etc., so graphically shown upon these traces, the writer became intensely interested in observing remarkable "wanderings" of the Horizontal Pendulum, first in one direction then in the other, often lasting for days, and sometimes sufficient to necessitate adjusting the levelling screw to keep the free end of the boom on the centre of the photographic paper.

Thinking these movements were caused by changes of atmospheric pressure, the writer has kept a continuous daily record of these "wanderings," large and small, of the pendulum, and for several years beginning with January, 1899, he has tabulated and plotted a curve of these movements. By studying this curve in conjunction with the Synoptic Weather Charts of the Pacific Slope for the same period the following information was obtained :—

When the barometer is low over the Pacific Slope from British Columbia to California, and low over the adjacent ocean, the Horizontal Pendulum is deflected eastward. When the barometer is high off the Coast and low over the Pacific Slope, the movement is towards the west.

The greatest movements occur during the stormy winter months, and the least during the summer type of almost continuous fine weather. These movements often commence some hours before the local barometer indicates an approaching change of air pressure.

In June, 1901, a paper by the writer entitled "The Seismograph as a Sensitive Barometer" was read at a meeting of the Royal Meteorological Society, London, and in the Autumn of the same year he had the privilege of personally presenting further data on the same subject at the British Association meeting held at Glasgow, and also had the pleasure of laying these plotted curves before Sir George Darwin at Cambridge. Sir George Darwin was surprised to observe such large movements of the horizontal pendulum under changes of air pressure, and the small effect due to the rise and fall of the ocean tides in this vicinity. He advised me to obtain more data, and to install a horizontal pendulum to swing North–South in order to study this direction of tilting along with the present East–West pendulum and the general changes of atmospheric pressure.

Although the writer has succeeded in keeping a continuous record of the movements of the East–West pendulum, it was not until January, 1907, he was enabled to personally construct a simple form of Milne Pendulum and set it up (to swing North–South) in the basement of the Post Office Building upon the solid rock, and about 500 feet distant from the East–West pendulum. From then to the present time most interesting results have been obtained from these instruments.

I take pleasure in bringing before this Society plotted curves showing the daily movements of both pendulums and the mean daily temperature from February 1st, 1907, to January 31st, 1908.

The vertical lines indicate 24-hour periods and the horizontal ones millimetres; the upper curve represents the movements of the East–West pendulum whose period of vibration is 15 seconds and its angular value 0·76. The intermediate curve shows the movements of the North–South pendulum which,

having only a 10-second period of vibration, is not so sensitive as the East–West instrument. The lower curve gives the mean daily temperature.

In studying these curves one cannot fail to observe a remarkable correspondence between the two pendulum plottings, that is, when the East–West pendulum swings west, the North–South one moves northward, and when the easterly swing is pronounced the other instrument travels to the southward.

Before describing the distribution of barometric pressure prevailing during several typical cases shown in these curves, the writer has found that when the barometric pressure is greatest from California northeastward to the Canadian Prairie Provinces, and low over the North Pacific Coast and British Columbia, the East–West pendulum moves east and the North–South instrument south.

When a vast area of high barometric pressure spreads southeasterly across Alaska to British Columbia and low barometric pressure prevails to the southward of this province, we find the East–West pendulum swings to the west, and the North–South one to the north, that is to say, both pendulums move in the direction of the greatest load on the earth's surface due to differences of atmospheric pressure.

The following are a few examples to more clearly explain this interesting phenomenon :—

Beginning with February 1st, 1907, and turning to the plotted curve already described, you will observe a rapid westerly swing amounting to 6 millimetres or 3″ in six days, while the other pendulum, which is not so sensitive, moved one millimetre towards the north. By turning to the Victoria Weather Charts for this period we find on the 1st of February a vast anticyclonic area (centre 31 inches) and cold wave over Alaska, while off the Coast of Vancouver Island there was an important low pressure area with a centre less than 29·80 inches. During the 2nd and 3rd the centre of the Northern High (over thirty-one inches) hovered over Alaska and the Yukon Territory, while the ocean cyclonic area spread towards the Coast where it caused an east-

erly gale. On the morning of the 6th the air pressure rapidly increased over the States of Oregon and Washington, and the Northern High area spread southeastward across the Rocky Mountains, giving place to low barometric pressure. This change caused the commencement of the remarkable easterly swing of 11 millimetres in four days, and a corresponding southerly movement of the other pendulum. From this date to the close of the month there was almost a continuance of high barometric pressure extending from the south and east of Vancouver Island, while to the west and north low pressure prevailed. The plotted curves for this period show a marked easterly movement and a moderate southerly swing.

In the month of March we find from the 2nd to the 17th a remarkable tendency for one pendulum to swing west and the other north. During this period a number of low barometer areas from the Pacific spread inland across California, while either over Vancouver Island or to the north and west of this the barometer was comparatively high and northerly winds prevailed.

A good illustration of a marked southerly movement is to be found on November 25th, 1907, when high barometric pressure prevailed from California eastward, and an important cyclonic area spread rapidly eastward to the north of Vancouver Island, this caused a steep barometric gradient over this province.

During the first few days of December there is a pronounced easterly and corresponding southerly swing, followed at the close of the month by a remarkable approach of the two curves, which is again even more pronounced at the close of January, 1908. During the latter movement a vast high barometer area and cold wave spread southeastward from Alaska. The mean daily temperature curve for this period shows a remarkable fall in temperature over this portion of the Province.

The mean temperature curve is given for the year under discussion to show the correspondence between it and the movements of the East-West pendulum movements, that is, when the former indicates a rising temperature, the latter, either at the time or shortly after, swings towards the eastward, and with a

falling temperature towards the westward. A study of the synoptic weather charts shows that is what might be expected.

The following is a summary of information derived from the study of the two pendulums already described :—

At Victoria, situated upon the southern end of Vancouver Island, the movements of these pendulums demonstrate a tilting of the earth's surface in the direction where the pressure of the atmosphere is greatest.

These pendulums often commence and continue swinging in a certain direction hours, and sometimes more than a day, before the barometers along the Pacific Coast indicate the approach of great cyclonic or anti-cyclonic areas from the ocean.

These pendular movements are greatest during the stormy months of winter and least throughout the summer when the changes of barometric pressure are small throughout the Pacific Slope.

To arrive at the true connection between pendulum movements and air pressure changes, the latter must be studied with charts covering areas of from one to two thousand miles in extent, otherwise the local atmospheric conditions may appear to cause a tilting effect contrary to that indicated by the pendulums.

The loading of the Pacific Slope during the winter months with heavy rains on the lower lands and great quantities of snow upon the great mountain ranges of the interior may account for a small proportion of the easterly tilting. The curves under discussion clearly demonstrate, however, that pronounced westerly tiltings occur during the winter months, when vast areas of high pressure hover to the westward of this. The curve for the first half of March, 1907, is a good illustration of this action.

From a careful perusal of the East–West Milne photographic record, the diurnal movement is found to be well marked upon fine days, and either absent or nearly so during overcast or rainy weather.

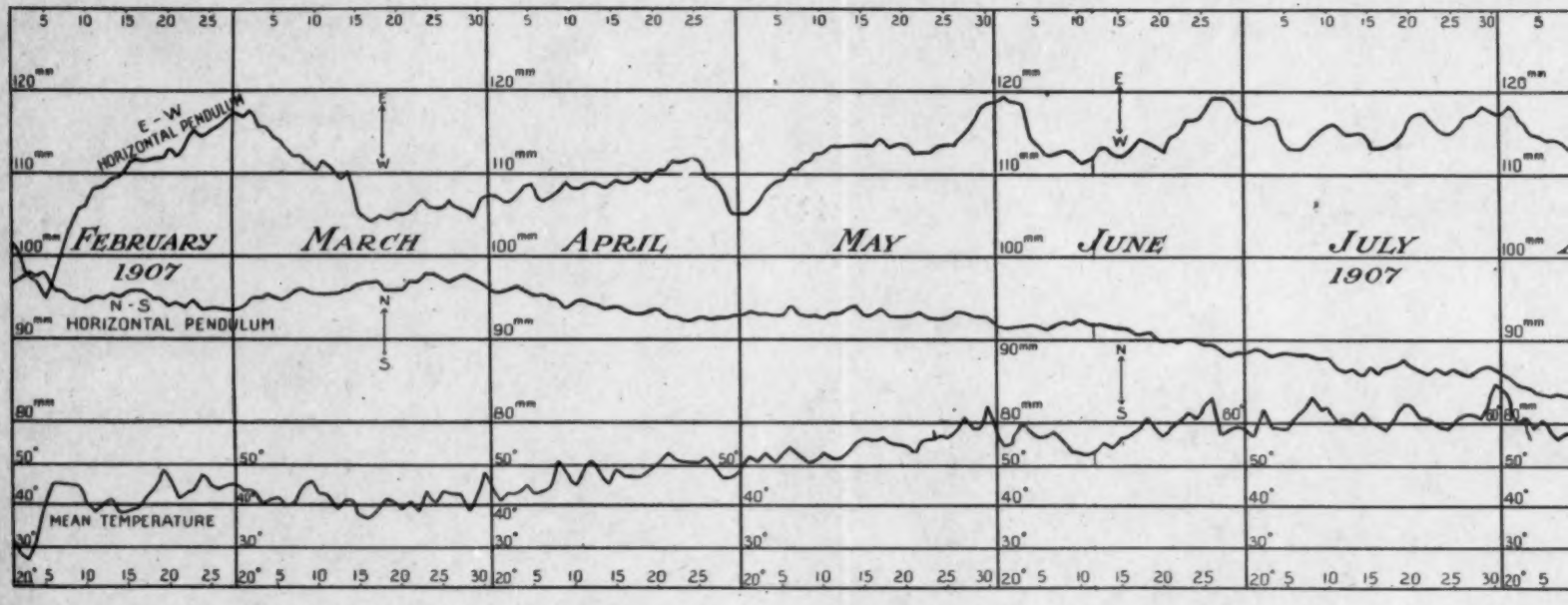
The loading effect upon the Coast due to tidal action is only noticeable upon the records, chiefly during the summer months, when little differences of barometric pressure prevail, and when

extreme tides occur. During unsettled weather, when great differences of air pressure are taking place over the Pacific Slope, the tidal effect on the pendulum is completely masked by the greater deflecting force.

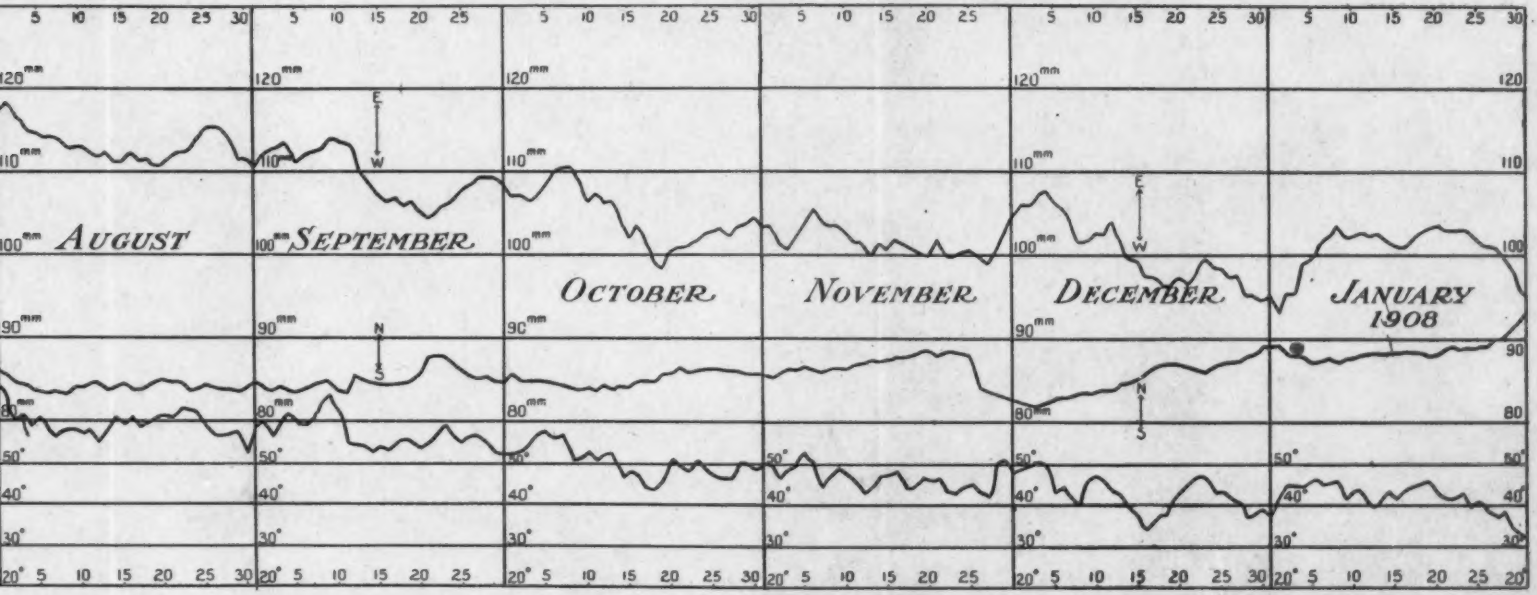
In conclusion, it is the writer's intention of increasing the value of future local observations of this phenomenon by installing another horizontal pendulum at the city of Vancouver, and through the courtesy of the Grand Trunk Pacific engineers at Prince Rupert, another under their supervision at that northern town.

It is hoped the above notes may throw further light upon a subject so ably treated by Sir George Darwin, Professor Milne and others, and may lead to a more complete study of this most interesting subject in other portions of the scientific world.

EAST-WEST AND NORTH-SOUTH HORIZONTAL PENDU



NDULUM MOVEMENTS AT VICTORIA, B.C., 1907-1908



THE ECLIPSES OF LARISSA AND THALES

By W. H. S. Monck

I THINK Mr. Jennings has sufficiently destroyed the credit of Xenophon's account of the Eclipse of Larissa to render it useless for scientific purposes. If we are to reject his statements that the original inhabitants of Larissa were Medes and that they abandoned Larissa during the war between the Medes and the Persians, on what authority do we adhere to his further statement that they abandoned it on account of a cloud passing over the Sun (even if that necessarily meant an eclipse). The chances are, I think, that the people in this district connected the traditions of the eclipse of Thales with the abandoned city. It would be strange indeed if two contests, in both of which the Medes were one of the parties engaged, were terminated by different solar eclipses within the short space of eighteen years. The most reasonable solution, I think, is that only one contest was thus terminated, and that, as regards that contest, Herodotus is the most reliable authority.

But in considering the eclipse of Thales, a somewhat fuller account of what Herodotus says of the early Median Kings seems a necessary introduction. Phraortes, the second King, was a warlike monarch who largely extended the limits of Media by conquest, but ultimately, in attempting to conquer the Assyrians, he perished with the greater part of his army. Cyaxares, his son and successor, resolved to avenge him. Having reorganized his army, he led it against the Assyrians, and won a victory over them; but they were saved for the time by an invasion of the Scythians, who defeated Cyaxares and took from him his father's conquests, though permitting him (as I infer) still to rule over the Medes. This Scythian supremacy lasted twenty-eight years. Ultimately Cyaxares threw it off and recovered his former terri-

tories, and he successfully renewed his attack on Nineveh and the Assyrians. He also waged a war of five years' duration with the Lydians, which was terminated by the eclipse of Thales. This was followed by a peace and the marriage of the daughter of the Lydian King to Astyages the son of Cyaxares. The reign of Cyaxares lasted forty years including the 28 years of Scythian domination. Allowing 2 years for his reign previous to his defeat of the Scythians, we have ten years left for his reign after the expulsion of the Scythians, and during this ten years he carried on both the war against the Assyrians and the war against the Lydians. An interval of 15 or 20 years between these two wars is completely excluded unless we suppose one of them to have been carried on during the period of Scythian domination. I should state that in one passage the figures given by Herodotus imply a duration of 22 years for the Scythian rule. This would allow six years more by the later exploits of Cyaxares.

Astyages succeeded Cyaxares, and after a reign of 35 years he was deposed by his grandson Cyrus, who was the son of his daughter Mandane. As Astyages was married in his father's life-time there is no difficulty in his having a grandson capable of leading an army when he had reigned 35 years, and Herodotus is quite clear as to the relationship, the length of the reign and the deposition, though he says Cyrus kept Astyages with him till the latter died. This war between the Medes and Persians, which thus ended in the triumph of Cyrus, took place about B. C. 557 and led to the eclipse of that year being identified with the eclipse of Larissa already referred to. Astyages' reign of 35 years thus gives approximately B. C. 592 for the date when he succeeded his father Cyaxares ; and as the eclipse of Thales took place within the life-time of Cyaxares, it must (according to Herodotus) have taken place before B. C. 592. We cannot identify it with the eclipse of B. C. 585 without supposing that Herodotus has blundered to such an extent as to render his entire narrative unreliable for any scientific purpose.

Taking the date of the fall of Babylon as B. C. 536, and assuming that Astyages completed his reign of 35 years in B. C.

557 or thereabouts, his marriage to the Lydian princess took place nearly 60 years before the fall of Babylon, and he must have been much more than 62 years old at that date.

Mr. Jennings seems to think that Astyages succeeded to the crown at or very shortly after his marriage-day in B. C. 584—whence Cyaxares' reign of forty years would have commenced in B. C. 624. This would bring (adopting Mr. Jennings' dates) the conquest of Nineveh (in conjunction with Nebuchadnezzar—but Herodotus does not mention the latter in this connexion) into the middle of the period of Scythian domination. This seems very unlikely as well as opposed to the narrative of Herodotus. To reach B. C. 585 as the date of the eclipse we must, I think, lengthen the reign of Cyaxares as well as shorten that of Astyages, besides representing Cyrus as the son or nephew instead of the grandson of the latter.

Whether there was any eclipse that agreed with the whole of the description of Herodotus may be doubted, and I shall not attempt to find one. But I think the eclipse of B. C. 585 is more inconsistent with his narrative—at least if Mr. Jennings' date for the Assyrian expedition be correct—in an unexpected way. We learn, not from Herodotus but from other sources, that Nebuchadnezzar joined Cyaxares in this expedition, the date of which is given as B. C. 609. Herodotus mentions Nebuchadnezzar (under his *alias* of Labynetus) as having acted as one of the peace-makers in arranging the treaty between the Medes and the Lydians. If this treaty took place in B. C. 610 we can easily see why Nebuchadnezzar should have exerted himself to bring it about, and why, as soon as the army of Medes was thus set free, the two allied monarchs proceeded with the invasion of Assyria, which both had probably previously meditated, and Cyaxares had actually attempted, when the Scythians attracted his attention elsewhere. The difficulty remains, however, of reconciling this date with the known lengths of the reigns of Cyaxares and Astyages and of the Scythian domination. Perhaps the date B. C. 603 involves the fewest difficulties, but I do not regard it as free from objection.

To verify a hypothesis by a comparison with facts the facts themselves should be certain. If we find that the narrative which we are following is erroneous in one respect our confidence in its other details must be considerably shaken, while if the account is so vague that several different statements of fact will satisfy it, the agreement of one of these with our hypothesis proves nothing at all. And above all we must avoid reasoning in a circle—using our hypothesis to decide between the different statements of fact which appear equally admissable, and then appealing to the result arrived at in this manner as confirming our hypothesis. The early accounts of eclipses are for the most part vague and probably inaccurate. Few if any of them can be relied on as tests of any hypotheses. We cannot prove that a hypothesis accords with the facts unless the facts have been clearly ascertained without the aid of the hypothesis. This, I think, is not the case with the Eclipses of Thales or of Larissa, if they be not the same.

Mr. Jennings has, I think, overlooked the fact that Herodotus mentions two expeditions of Cyaxares against the Assyrians, one being apparently his earliest and the other his latest campaign, with the entire period of Scythian domination occurring between them. The capture of Nineveh would seem to have taken place near the end of his reign, though his earlier invasion occurred some thirty years before. It will not, however, assist us much if we suppose the evacuation of Larissa (or Calah) to have taken place during the earlier invasion, unless we make a large change in the date of the capture of Nineveh.

With regard to Darius the Mede we have only conjecture to guide us. Herodotus, however, mentions Harpagus a Mede, a kinsman of the King who had saved Cyrus' life and was instrumental in placing him on the throne. He was frequently entrusted with a separate command, and probably exercised regal functions in the countries entrusted to his care, while Cyrus was busy pursuing his conquests elsewhere.

PAPERS PRESENTED TO THE SOCIETY 1890–1905

THE Annual Reports of the Society, first under the name of the Astronomical and Physical Society of Toronto, then as the Toronto Astronomical Society and finally as the Royal Astronomical Society of Canada, were published from 1890 to 1905. The papers contained in them are not fully indexed, and the present List was prepared under the direction of the Librarian, and presented to the Society. Much interest was shown in the List, and a desire was expressed that it be published.

ABREY, GEORGE B.,

Astronomical Instruments used in Surveying,	February 10, 1891.

ALLEN, J. A.,

Grant Allen's Theory of "Force and Energy,"	February 6, 1894.

ATKINSON, REV. ROBERT,

Mercury,	March 6, 1900.
The Eclipse as seen from the Moon,	April 17, 1900.
Great Nebula in Andromeda,	September 18, 1900.
The Moon,	April 16, 1901.
What may be done with a 3-inch Telescope,	November 25, 1901.
Personal Profit from Astronomical Study,	1905.

BAKER, PROF. ALFRED, M.A.,

The Nebular Hypothesis,	April 26, 1898.

BARR, J. MILLER,

Observations on Variable Stars,	1904.
New Variable Stars,	1905.
The Colors of Helium Stars,	1905.
A New Problem in Solar Physics,	1905.

BELL, CLARENCE,

Electricity and Electrical Units,	July 28, 1891.
Electricity,	August 12, 1891.
The Construction and Theory of the Dynamo,	April 19, 1892.

BICKERTON, PROF. A. W.,
The Energy of Stellar Collision, 1904.

BORGSTRÖM, DR. L. H.,
The Shelburne Meteorite, 1904.

BRASHEAR, DR. J. A.,
Diffraction Gratings, May 28, 1899.

CARPMAEL, CHARLES, M.A.,
Annual Address, February 24, 1891.

CHANDLER, S. C.,
Some Novel Stellar Motions, March 22, 1892.

CHANT, DR. C. A.,
The Polarization of Light, April 18, 1893.
Electrical Radiation, November, 26, 1905.
Experiments with X-Rays, March 3, 1896
Dr. Zeeman's Discoveries, June 24, 1897.
Standing or Stationary Light Waves, May 1, 1900.
Some New Aspects of Ether Waves, October 29, 1901.
New Determinations of the Reflecting Powers of Glass and Silvered-glass Mirrors, 1904.
Astronomical and Astrophysical Progress in 1905, January 23, 1906.

CLARK, J. M., M.A., LL.B.,
Energy, March 8, 1892.

CLARKE, H. L.,
The Life History of Star Systems, August 4, 1896.

CLERKE, MISS AGNES M.,
Nova Aurigæ, July 12, 1892.
Distance of the Nebulæ, October 31, 1893.

CLOUGHER, T. R.,
The Experiences of an Amateur in Popularizing Astronomy, December 27, 1900.

COLEMAN, DR. A. P.,
Theories in World Building, 1904.

COLLINS, J. R.,
Force and Energy, February 20, 1894.
Aurora of February 23rd, March 5, 1894.
Magnetic Stress, April 17, 1894.
Theories of Universal Gravitation, December 23, 1895.

Construction of Telescopes, July 7, 1896.
The Retrograde Motion of the Moons of Uranus, October 28, 1897.
Schaeberle Aberration in the Telescope, January 6, 1898.
What Professional Astronomers hope to Discover, April 17, 1900.
The Phenomena of Surface Reflection of Light, June 26, 1900.
Recent Criticisms of the Nebular Hypothesis, October 2, 1900.
Radium, 1902–3.
Man's Place in the Universe, 1904.

COLLINS, Z. M.,
Ancient and Modern Theories of the Aurora, March 19, 1901.

CONNOR, J. R.,
Aurora of July 15th, August 8, 1893.

COPLAND, J. A.,
Holmes' Comet, March 21, 1893.
Aurora of July 15th, 1893, August 8, 1893.
Brooks' Comet, December 26, 1893.
The Canals of Mars, " 10, 1895.
Lunar Phenomena, February 4, 1896.

CRAIG, MRS. GEORGE,
Popularizing Astronomy, January 6, 1898.

DE LURY, A. T., M.A.,
The Eclipse Expedition to Labrador, August, 1905, 1905.

DENISON, F. NAPIER,
The Air Barometer, May 11, 1897.
Our Atmospheric Ocean, June 14, 1898.

DENNING, W. F., F.R.A.S.,
New Nebulæ, December 29, 1891.
Meteoric Observations, September 6, 1892.
Radiant Point of the Perseid Meteor Shower, December 12, 1893.
Comets of Short Period, August 21, 1894.
The Observation of Shooting Stars, November 13, 1900.
The Planet Jupiter and his Markings, February 5, 1901.

DENT, MISS ELSIE A.,
Biographical Sketch of M. Camille Flammarion, September 3, 1901.
Biographies of our Honorary Corresponding Fellows,
Women's Work in Astronomy, 1902–3.

DEWAR, ROBERT,
A Plea for the Terms "Atom" and "Molecule," February 23, 1892.

DONALDSON, DR. J. C.,

Auroral Displays,	July 26, 1892.
The Transit of Mercuy,	November 13, 1894.
Star Observations,	December 27, 1894.
Double Star Observations,	April 16, 1895.
The Dark Spot on Jupiter,	May 14, 1895.

ELVINS, ANDREW,

The Probability of Great Discoveries in Astronomy During the Next Decade,	February 25, 1890.
Moving Matter,	November 4, 1890.
The Great Red Spot on Jupiter,	March 10, 1891.
Planetary Rotation,	May 5, 1891.
Moving Matter,	September 8, 1891.
Annual Address,	January 12, 1892.
Great Sun-Spots,	July 12, 1892.
Auroral Displays,	July 26, 1892.
New Jovian Satellites,	October 4, 1892.
Moving Matter,	November 1, 1892.
" " Solar Heat,	May 30, 1893.
" " " "	July 25, 1893.
Terrestrial Magnetism,	October 30, 1893.
Meteorology,	" 16, 1894.
Earthquake and Volcanic Phenomena,	March 19, 1895.
The Moon's Present Condition,	July 23, 1895.
Planetary Mass and Atmosphere,	March 17, 1896.
Rays of Energy,	June 9, 1896.
Planetary Rotation,	June 24, 1897.
Lunar Observations,	September, 14, 1897.
Lunar Sketches,	January 6, 1898.
Experiments in Color,	April 14, 1898.
The Great Sun-Spot of September 4-15th,	September 20, 1898.
World Formation and Dispersion,	March 7, 1899.
Meteorology,	July 11, 1899.
The Tides,	November 28, 1899.
Zodiacal Light,	March 6, 1900.
The Eclipse as Seen from the Sun,	April 17, 1900.
Lunar Rays,	May 29, 1900.
Notes on World Formation by Accretion,	February 5, 1901.
Deformed Lunar Craters,	October 1, 1901.
The Constitution of Matter,	1902-3.

ESPIN, T. E.,

New Companions to Double Stars in Webb,	January 10, 1893.

FOSTER, DR. G. B.,

Electricity and its Use in Medicine,	June 30, 1891.

GOLDIE, JOHN,

Paraselene of March 19th,	March 22, 1892.

GORE, J. ELLARD,

The Pleiades,	November 16, 1891.
Stellar Distances and Motions,	June 28, 1892.
Lumineferous Ether,	November 28, 1893.
Spectroscopic Binary Stars,	September 18, 1894.

GRAHAM, L. H.,

Nineteenth Century Astronomy,	1905.

GRAY, MISS A. A.,

The Proposed Change in Reckoning the Astronomical Day,	January 9, 1894.

HADDEN, DAVID E.,

Rordame's Comet,	August 8, 1893.
Solar Prominences,	June 24, 1894.
The Transit of Mercury,	November 13, 1894.
Solar Observations,	October 1, 1895.
The Solar Eclipse of July 29th,	August 3, 1897.
The Great Sun-Spot of September 4-15,	October 4, 1898.

HAHN, DR. OTTO,

Meteorites,	January 10, 1893.

HALE, GEORGE E.,

Photographing Faculæ,	March 22, 1892.

HAMILTON, J. C., M.A., LL.B.,

The Pleiades,	September 17, 1901.
Stellar Legends of American Indians,	1905.

HARVEY, ARTHUR,

Astrolabes, including that of Champlain,	November 3, 1891.
Photochromy,	December 1, 1891.
Electric Storm,	July 26, 1892.
Solar Eclipse of October 20th,	November 1, 1892.
The Telescope,	February 21, 1893.
The Simple Mathematics of Saturn,	March 21, 1893.
Mathematics of Saturn,	April 4, 1893.
The Pythagorean Philosophy,	June 15, 1893.
Aurora of July 15, 1893 (its Parallax),	August 8, 1893.
Experiments in Reflecting Solar Light,	August 22, 1893.
Astronomical Notes on the Sun,	September 19, 1893.
Liquefaction of Gases,	June 26, 1894.

HARVEY (*Con.*)

South Polar Regions of the Earth and Mars,	August 7, 1894.
The Destiny of the Nebulæ,	January 22, 1895.
The Lunar Eclipse of March 10th,	March 19, 1895.
The Behavior of Minerals at Very High Temperatures,	April 30, 1895.
On the Rings of Saturn,	August 20, 1895.
The Contrast between Lunar and Terrestrial Features,	September 3, 1895.
The Rœntgen Discoveries,	February 4, 1896.
Meteors,	July 21, 1896.
Foci of Solar Activity,	March 2, 1897.
The Solar Eclipse of July 29th,	August 3, 1897.
Periodicity of Magnetic Disturbances,	October 12, 1897.
Recent Developments in the By-ways of Astronomy and Physics,	January 25, 1899.
Notes on Andromedes,	March 21, 1899.
An Aureole about Mercury,	May 16, 1899.
Astronomy in Infancy, Youth and Maturity,	January 23, 1900.
Aurora Borealis,	October 16, 1900.
The Sun,	January 22, 1901.
Synchronism of Northern and Southern Auroræ,	March 19, 1901.
Great Comets.	May 14, 1901.
Shooting Stars vs. Uranoliths.	1902-3.
The Astronomical Equipment of Canada.	1902-3.
Greenwich Observatory.	1902-3.
Solar Phenomena and Terrestrial Effects.	1902-3.
Solar Spots and Magnetic Storms for 1904.	1905.

HOLLINGWORTH, JOHN,

Auroral Display.	July 26, 1892.
Precipitation of Rain	February 18, 1896.

HOUSTON, WILLIAM, M.A.,

Astronomy in the Provincial University,	May 17, 1892.

HOWELL, D. J.,

Color Photography,	October 16, 1900.
Recent Lunar Photographs,	1904.

HULL, G. F.,

Color	April 3, 1894.
The X Rays,	April 14, 1896.
The Pressure of Light and its Application in Astronomical Problems.	December 23, 1901.

HUNTER, A. F.,

Application of the Polarization of Light,	November 10, 1896.

KEELER, JAMES E.,

On a Lens for Adapting a Visually Correct Telescope to Photograph Observations with the Spectroscope,	October 16, 1894.

KING, DR. W. F., Chief Astronomer,

The Dominion Observatory at Ottawa,	1905.

KIRKWOOD, PROF. D.,

Rotation Period of Mercury and Venus,	January 13, 1891.

KIRSCHMANN, PROF. A.,

Life in Other Worlds,	1905.

KLOTZ, OTTO, LL.D.,

Transpacific Longitudes,	1905.

LINDSAY, THOMAS,

A Method of Computation of Eclipse Projection,	March 11, 1890.
Astronomical Predictions,	December 16, 1890.
The Transit of Mercury, May 9, 1891,	March 24, 1891.
Lunar Parallax,	October 20, 1891.
The Partial Solar Eclipse of October 20th, 1892.	" " "
Approaching Occultation of Mars, July 11th,	June 14, 1892.
Work for Amateurs,	November 29, 1892.
Planetary Rotation,	May 16, 1893.
Occultation of Antares,	July 11, 1893.
The Chemistry of the Atom,	October 17, 1893.
Fallacies of Mathematics and Astronomy,	May 1, 1894.
The Transit of Mercury of November 10, 1894,	October 2, 1894.
The Origin of the Nebulæ	January 22, 1895.
The Lunar Eclipse of March 10th,	March 19, 1895.
Historical Sketch of the Greenwich Nautical Almanac,	July 9, 1895. October 27, 1896. November 11, 1897. January 20, 1898. May 31, 1898. March 21, 1899.
Occultation of Jupiter,	June 23, 1896.
The Total Solar Eclipse of May, 1900,	July 20, 1897.
The Canals of Mars,	April 14, 1898.
Planets and the Weather,	April 4, 1899.
A Visit to Yale Observatory,	August 22, 1899.
Total Eclipse of the Sun, May 28, 1900,	October 3, 1899.
Solar Eclipse of May 28, 1900,	February 20, 1900.
Venus,	March 28, 1900.
Solar Eclipse of May 28, 1900,	June 12, 1900.
Recurrence of Eclipses,	November 13, 1900.

LOUDON, PROF. J., M.A., LL.D.,

The Interference of Sound,	February 16, 1897.

LOUDON, W. J.,

A Lunar Tide on Lake Huron,	1905.

LUMSDEN, G. E.,

Constellation Study,	January 27, 1891.
A Plea for the Common Telescope,	April 21, 1891.
The Face of the Sky for November,	November 3, 1891.
Occultation of Uranus, April 12,	April 19, 1892.
Swift's Comet,	May 3, 1892.
Planetary Motions,	May 31, 1892.
Discoveries upon Mars,	Septemoer 26, 1892.
Astronomical Phenomena,	February 7, 1893.
Astronomical and Physical Exhibits at the World's Fair	December 12, 1893.
The Eclipse of the Moon,	March 19, 1895.
Parhelion, March 14,	" " "
Celestial Photography,	November 12, 1895.
Black Aurora,	March 2, 1897.
The Necessity for Individual Effort,	June 8, 1897.
The Nautical Day,	September 28, 1897.
A Popular Astronomical Observatory,	July 12, 1898.
Total Eclipse of the Sun, May 28th, 1900,	October 3, 1899.
The Eclipse as seen from Venus,	April 17, 1900.
The Eclipse of May 28th, 1900,	June 12, 1900.
Annual Address,	January 10, 1901.

MCBRIDE, REV. F. J.,

Approximations,	May 16, 1893.
The Small Mass of the Earth,	" " "

MARSH, REV. DR. D. B.,

Photographing the Sun and Moon,	1905.

MAUNDER, E. WALTER, F.R.A.S.,

Magnetic Disturbances 1882-1903,	1904.

MAYBEE, J. EDWARD, M.E.,

Liquid Air,	February 6, 1900.
Construction of Planispheres,	April 3, 1900.
Some Contributions of Astronomy to Practical Life and Thought,	November 27, 1900.
Is the Moon a Dead World?	1902-3.

MEREDITH, E. A., LL.D.,

The Chemistry of Steel Making,	July 23, 1895.
The November Meteors of 1832-3,	March 30, 1897.
The Expected Meteors of November, 1898,	November 1, 1898.

MILLER, A. F.,

An Introduction to the use of the Spectroscope,	April 8, 1900.
The Use of the Spectroscope,	July 15, 1900.
Amateurs' Study of Double Stars,	June 16, 1891.
Peculiar Hydrogen Cloud,	June 14, 1892.
Great Sun-Spots,	July 12, 1892.
The Spectrum of the Light Emitted by Insects,	July 25, 1893.
The Spectra of the Nebulæ,	March 5, 1895.
Spectroscopic Observations of the Moon,	March 19, 1895.
Coincidence of Spectral Lines, Argon and the Nebulæ,	April 30, 1895.
Observations of the Sun,	September 3, 1895.
Lunar Eclipse, September 3-4,	September 17, 1895.
Measurement of Absolute Wave-Length	April 13, 1897. April 27, 1897.
The Solar Eclipse of July 29th,	August 3, 1897.
Venus,	March 6, 1900.
The Examination of Solar Prominences during Eclipses	April 17, 1900.
Earth,	October 30, 1900.
Observations of Nova Persei,	December 23, 1901.
Spectrum of Light Reflected from Salts of Uranium,	1902-3.

MONCK, W. H. S., F.R.A.S.,

Stationary Meteor Radiants,	June 10, 1899.
A Catalogue of Aerolites,	1902-3.
Aerolites,	1904.

MORRISON, DR. J.,

The Disappearance of Saturn's Rings,	December 30, 1890.
Solar Heat,	December 15, 1891.
Solar Parallax and Sun's Distance,	May 29, 1894.
Special Perturbations,	December 27, 1894.

MUSSON, W. B.,

Mythology of Jupiter,	January 23, 1894.
The Variable Star Algol,	December 9, 1897.
A Visit to the Yerkes Observatory,	August 23, 1898.
Some Ancient Theories Regarding Motion and the Cosmos,	September 20, 1898.
Search for Intramercurial Planets During Eclipses,	April 17, 1900.

MUSSON (*Con.*)

Stellar Evolution,	October 15, 1901.
Variability of the Light of Stars,	1902-3.
Astrophysical Research,	1904.
Stellar Classification,	1905.

PATERSON, JOHN A., M.A., K.C.,

Before the Beginning,	December 27, 1892.
Annual Address,	January 9, 1894.
The Progress of Astronomy in 1894,	January 8, 1895.
The Progress of Astronomy in 1895,	January 21, 1896.
Meteoric Showers,	August 11, 1896.
The Progress of Astronomy in 1896,	January 19, 1897.
The Progress of Astronomy in 1897,	February 3, 1898.
Tidal Phenomena as revealed in the Genesis of Worlds	1899.
Art and Astronomy,	December 11, 1900.
The Apex of the Sun's Way,	1902-3.
The Astronomy of Tennyson,	1905.

PEAL, S. E.,

The Canals of Mars,	April 4, 1893.
On Professor Weinck's Enlargements of the Lick Photographs of Lunar Craters,	November 27, 1894.
Problems in Selenology—What does "Tidal Retardations" on the Moon Imply?	March 31, 1896.

PHILIPS, JOHN,

How our Moon found her Orbit.	December 30, 1890.
The Position of the Lunar Orbit,	March 10, 1891.
How our Satellite may have found her Orbit,	November 15, 1892.
Retrograde Motions of the Moons of Uranus,	May 7, 1893.
The Volcanic Theory of Planetary Projection,	October 30, 1893.
The Nebular Hypothesis of Laplace,	September 11, 1894.
Conservations of Areas,	August 6, 1895.
The Rings of Saturn and the Nebular Hypothesis,	October 15, 1895.
The Genesis of the Moon on the Theory of Vertical Projection and Tidal Action,	December 27, 1900.

PICKERING, PROF. E. C.,

A New Type of Double Stars,	June 3, 1890.

PLASKETT, J. S.,

Color Photograpy of the Corona,	1905.

POPE, JOSEPH, C.M.G., F.R.S.C.,

Halley's Comet, May 14, 1901.

PURSEY, G. G.,

Imponderable Matter, May 19, 1891.
Saturn as a Habitable Globe, March 21, 1893.
Solar Heat, May 2, 1893.
Solar Observations, March 31, 1896.

RICHARDSON, C. GORDON,

The Fractionating Process in Inorganic Chemistry, March 25, 1890.

RIDGEWAY, R.,

Historical Sketch of the Progress of Astronomy from the Earliest Ages to the Christian Era, June 2, 16, 1891. July 14, 1891.

RIDOUT, JOHN G.,

Solar and Lunar Parallax, October 21, 189[illegible].
Ocean Tides, Currents and Winds, April 7, 1891.

ROSS, HON. G. W.,

The British Association, May 14, 1895.

SAVIGNY, MRS. ANNIE,

Conditions under which the Inhabitants of Jupiter (if any) would Exist, January 23, 1894.
Star Clusters and Nebulæ, January 22, 1895.
The "Planet Mars," July 6, 1897. September, 14, 1897.
Observations at Lowell Observatory, December 26, 1899.
Lowell Observatory April 3, 1900.

SHEARMEN, T. S. H.,

Coronal Photography in Full Sunshine, August 26, 1890.
Observing the Solar Corona by Fluorescence, November 4, 1890.
Solar Disturbances and Terrestrial Magnetsm, June 2, 1891.
The Oblique Cassegrain, April 30, 1895.
Solar Corona Observations during Sunrise, June 9, 1896.
Black Aurora, April 14, 1898.
The Connection between the Different Classes of Solar Disturbance and Terrestrial Magnetic Disturbance, November 15, 1898.

STEWART, PROF. LOUIS B.,

Gravity Determinations in Labrador, 1905.

STUPART, R. F.,

The Development and Progress of Areas of Depression,	July 24, 1894.
Seismological Phenomena,	July 31, 1898.
The Magnetic Observatory at Agincourt,	October 18, 1898.
Seismology,	May 15, 1900.
Sun-Spots and Precipitation,	April 2, 1901.
Electrical Disturbances during Auroral Displays,	December 10, 1901.
Annual Address	January 20, 1903.
Astronomical and Astrophysical Progress During 1904,	January 10, 1905.
Magnetic and Meteorological Odservations at North-West River, Labrador,	1905.

TAYLOR, MISS S. L.,

The Planet Saturn,	March 21, 1903.

TURNBULL, MUNGO,

Transits of Mercury and Venus,	May 5, 1891.

VALE, MISS KATHERINE E.,

The Chamberlin Observatory,	September 18, 1894.

VAN SOMMER, J.,

The Form of the Aurora,	September 11, 1894.
Notes on Auroral Displays,	April 2, 1895.

VEEDER, DR. M. A.,

Zodiacal Light,	April 5, 1892.
Lunar Auroral Streamers,	December 27, 1892.
The Source of Solar Heat,	May 16, 1893.
Aurora of July 15th,	August 8, 1893.
Auroræ,	October 28, 1897.

WADSWORTH, DR. J. J.,

Observations of Saturn,	July 9, 1895.
Notes on Lunar Study,	December 10, 1895.
Observations of Jupiter,	March 17, 1896.
Observations of Saturn,	September 29, 1896.
The Solar Eclipse of July 29th,	August 3, 1897.
The Eclipse as Seen from the Moon,	April 17, 1900.
The Moon,	April 16, 1901.

WATSON, DR. A. D.,

The Reform and Simplification of the Calendar,	September 29, 1896.
Graduation of the Thermometer,	November 12, 1896.

WATSON, JOHN, M.A., LL.D.,

The Relation of Philosophy to Ancient and Modern Cosmogonies, 1904.

WEATHERBE, J. H.,

The Path of the Planets in the Sky, March 19, 1901.

WINDER, D. K.,

Telluric Lines in the Spectrum of Mercury, June 2, 1891.

MEETINGS OF THE SOCIETY

AT TORONTO

November 3.—Mr. Hassard gave a report of his recent observations. He stated that, on examining Saturn's rings more carefully, he had come to the conclusion that Mr. Miller's objection at the last meeting was well taken, and that he had been mistaken in thinking that he had detected the crepe ring. The space between the planet and ring was clearly perceptible, and he had observed the satellites Titan and Rhea. He had searched for Comet Morehouse, but failed to find it. He stated that he had been able to find the companion of Polaris in bright moonlight, but not the companion of Aldebaran. A very large spot is visible on the Sun at present, probably covering a diameter of 10,000 miles. Mr. Hassard reported his progress in making a telescope, and pleaded for an increase in the number of practical observers in the Society, stating that instruments might be made by the members themselves without much difficulty. He also explained his method of polishing the mirrors. Mr. Hassard's remarks and reports of his work were heard with deep interest.

The paper was by Mr. R. Stewart Muir, on "Comets," having particular reference to Halley's Comet and the different classes of cometary objects. Slides were shown illustrating the address, and an interesting discussion followed.

November 17.—The following was elected a member of the Society:

Lawrence V. Redman, B.A., Toronto.

As to the question asked at a former meeting, asking for information as to the method followed in determining the orbits of comets, Professor De Lury, who was called on, said the subject was one that could not be dealt with in the time allotted to it to-night, and that it would form a suitable topic for a paper.

Reference was also made to a question asked at a recent meeting, respecting the cause of gravity. Mr. Collins mentioned

different effects of gravity, and stated that the cause is not known. Mr. Elvins took part in the discussion on the subject.

The Lecture was by Professor De Lury, upon the subject of "The Aberration of Light." An interesting account was given of the methods by which measurements are made and the effect of aberration, illustrated by blackboard examples.

December 1.—The following was elected a member of the Society :

Professor Richard Davidson, PH.D., University of Toronto, Toronto.

OBSERVATIONS :—Mr. Cuthbert raised the question as to whether the present is the year 1908 or the year 1909, and undertook to demonstrate on the blackboard that the correct number is 1909. Mr. Cuthbert defined "Time" as "The abstract of sequence," and an interesting discussion took place on the subject, in which Mr. Miller, Mr. Graham and others took part.

Under the heading of "Notes and Queries" the President referred to a report current in the newspapers, to the effect that Professor Rutherford, late of McGill, but now of Manchester College, is regarded as a possible recipient of a Nobel Prize, for his researches in respect of radium, etc.

The paper for the evening, by Mr. John A. Paterson, on the subject of "Art and Astronomy," dealt with the relation of different branches of the arts to astronomy, and was phrased in Mr. Paterson's always felicitous and poetical language.

E. A. D.

AT OTTAWA.

October 22, 3 P.M.—The Vice-president, Dr. Klotz, took the chair while Dr. King read his paper on "Some Remarks upon the Doctrine of Probability."

Dr. King explained the term *probability* and distinguished between frequency and probability, defining the former as the property of things or events, the latter as the state of our minds

by which we expect the frequency. Probability estimates our expectations while frequency determines whether we have judged correctly. The applications of probability to the method of least squares and in life insurance were briefly discussed; and then the inverse problem in which, having given the result, depending upon one or other of several causes, it is required to determine the probabilities of these causes.

Many interesting examples were given. The odds against two stars of the seventh magnitude being within 4″ of one another by chance have been calculated as 9,570 to 1 and of three stars 173,524 to 1, the conclusion being strong that such stars are connected by gravitation. Similarly there are odds of about 40,000 to 1 that the sextuple star in the great nebula in Orion is physically connected with it. Another example, referring to the markings on Mars, was also given.

Dr. King then applied the inverse method to determine the probability of statements supported by assertions or other evidence. The principles were again illustrated by numerous examples and some apparent paradoxes explained. The probabilities of traditionary testimony were also deduced with examples.

It was further shown that very high probabilities may be overcome by concurrence of evidence. Thus, if an event, whose probability of happening is only 1 to 1,000,000,000,000, have thirteen witnesses of credibility, $^{9}/_{10}$ in its favor, the odds will be more than even. A further astronomical illustration, referring to the probability that Alcyone was a central sun around which the Universe revolved, was also given.

The paper concluded with a discussion of the probabilities that, as pointed out in the paper by J. Miller Barr in a recent number of the Society's JOURNAL, about 26 out of 30 spectroscopic binaries have their nearer apses pointed away from the earth. The chances against such a coincidence were shown to be about 40,000 to 1, and the conclusion seems to be forced upon us that there is either some physical cause or some error in the observations, thus giving incorrect orbits.

November 6.—Before a large audience in the Assembly Hall of the Normal School Prof. A. T. De Lury gave his second lecture on "The Scheme of Things."

Professor De Lury first reviewed the ground covered in his previous lecture and then continued his discussion of the motions of the planets. He showed how by observing the greatest separation of Venus and the Sun we could get a proportional idea of the dimensions of its orbit as compared to that of the earth. When the relative sizes of the orbits of all the planets had been obtained by observation and by the use of Kepler's Laws we had the proportions of the solar system but not its absolute size. Professor De Lury then showed how the distance between the earth and the Sun, and consequently the dimensions of the whole system, could be obtained by observing the transits of Venus across the Sun's disc, which occur at somewhat rare intervals. After mentioning other means of obtaining this constant, the lecturer went on to speak of the physical cause or law which governed the harmonious and beautiful working of the system. The laws governing the motions and the proportions of the system were formulated by Kepler, as the result of a great number of observations, without any definite notion of the underlying physical cause. Professor De Lury then described how Newton attacked the problem, referring to the story of the fall of the apple, so often told, and related how the first attempt applied to the revolution of the Moon around the earth showed, with the then known data, that it could not be due to a force varying inversely as the square of the distance.

Shortly afterwards, when some new and more accurate observations had been obtained and reduced, Newton found by their use that the falling of the Moon towards the earth could be accounted for by the same force which caused any body at the earth's surface to move towards it, and that this force varied inversely as the square of the distance.

Newton in obtaining this wonderful result had to overcome many difficulties, to invent a mathematical method to solve the

problem, and Professor De Lury referred in suitable terms to the magnitude and far reaching importance of the work. It is found that the law of gravitation explains all the motions in the solar system, and, further, that when double stars are observed their motions can be shown to be governed by the same law, which therefore applies universally.

Professor De Lury closed his lecture by reading numerous extracts from poets and prose writers referring to the importance and value of astronomy, showing that it appeals not only to mathematicians and scientists but to poets and writers also.

November 19, 3 P.M.—Mr. J. S. Plaskett gave a paper on "Spectrograph Camera Objectives." After giving a short sketch of the history of the subject Mr. Plaskett pointed out the defects of the cemented single lens composed of either two or three elements. The field of sufficiently good definition only extends over two degrees, and the desirability of a field of 8° or 10° for work on early type stars was carried out. The excellent performance of the only lens so far constructed for overcoming this defect, the Hartmann–Zeiss "Chromat" was given, but unfortunately this cannot be made of larger angular aperture than $f/12$ and can not be used for work with a single prism.

The features of a number of lenses tested by Mr. Plaskett were then briefly described, especially of two expressly made for Ottawa to fill the need above mentioned. The method of determining the form of the focal curve was then fully described, this depending upon the datermination of the intersection point of two small eccentric pencils (which is, of course, the focus) by means of exposures within and without the focus.

Diagrams in the form of lantern slides were then shown, giving the form of field of 9 lenses tested.

A lens made by Brashear for use with a single prism spectrograph of two widely separated (by ⅓ the focal length) elements of the lightest crown glass made, gave not only exquisite definition, but a field flat over the whole visible spectrum and into the ultra-violet.

A Zeiss–Tessar lens and a special lens by Ross, the former of 12, the latter of 19-inch focus, satisfactorily supply the need of short focus lenses with three prisms, both giving good definition and flat fields. The fields given by these lenses were compared with those given by the lenses previously used with spectrographs, showing the very marked increase in flatness and extent of the field obtained.

Mr. R. M. Stewart presented a paper on "Some Electrical Anomalies."

Mr. Stewart described two curious electrical phenomena that occurred in connection with the transmission and distribution of time signals. The first of these, though it can not be called an anomaly, as it is readily explained by the known laws of electricity, was described and illustrated by an experiment in which it was shown that the E. M. F. induced on breaking a circuit containing self-induction was sufficient to actuate the armature of a polar relay. Mr. Stewart then described how this effect could readily introduce error in the time signals given by two chronographs connected in multiple with the same clock. The chronograph with the smaller self-induction would have a much sharper break than the other and would cause a difference in the recorded time of the signals. It was shown how this could easily be overcome by placing each chronograph on a separate relay.

Mr. Stewart then described the second phenomenon, which in this case could be classed as an anomaly, as no explanation could be given of it. It occurs in the distribution of the minute signals to the dials in the Departmental buildings. The dials are placed in series of 10 and these series are in multiple with the actuating relay and battery. The series circuits when complete work perfectly, but if, as in the case under consideration, there is only one dial in a circuit, this dial will not work properly, even if sufficient resistance is put in to make it equal to the resistance of the ten-dial circuits. If the resistance is made inductive also so that the inductance of the circuits becomes the same, still the dial will not work. It has been found by experiment that it can be made to perform fairly well by making the

resistance of the circuit about 60 per cent. greater than that of the ten-dial circuits so that only about ⅔ of the current required for the other dials is used. Mr. Stewart offered no explanation of this anomaly but left it an open question for the members.

December 3.—The annual meeting of the members at Ottawa of the Royal Astronomical Society of Canada was held in the Carnegie Library Lecture Room.

The President, Dr. W. F. King, occupied the chair.

The minutes of the last annual meeting were read by the Secretary and duly confirmed.

The President, after short introductory remarks, referring to the change in status of the members at Ottawa due to the new constitution of the Society which came into force on December 1, proceeded to the usual order of business and called for the report of the Secretary.

The report was read by Mr. Plaskett who moved, seconded by Dr. Klotz, its adoption.

The Treasurer's report was then read by Mr. Stewart, who, seconded by Mr. McDiarmid, moved its adoption.

The President then explained the new constitution and pointed out the changes it made necessary in the procedure and in the by-laws of the local organization. He explained the new titles required by the presiding officer and asked Dr. Klotz to read the new by-laws prepared by the Committee, which supersede the original by-laws. These by-laws were read and on motion of Dr. Klotz, seconded by Mr. Plaskett, were adopted without discussion.

Officers were elected as follows :—

Chairman, Dr. Otto Klotz,

Vice-chairman, J. S. Plaskett,

Secretary, Carl Engler,

Treasurer, R. M. Stewart,

Councillors, W. J. Stewart, Dr. W. Bell Dawson, Joseph Pope.

J. S. P.

AT PETERBOROUGH.

November 17.—The regular meeting of the Peterborough Centre of the Royal Astronomical Society was held in the Chemical Laboratory of the Collegiate Institute and was attended by a large number of members.

The President, Rev. Dr. Marsh, opened the meeting with a short report upon some observations he had recently made. Messrs. Fisk and Collier also reported some interesting observations they had made.

The following were elected members of the Society:

Rev. W. H. Elmsley, M.A., Napanee,

Hon. J. R. Stratton, M.P., Peterborough.

The feature of the evening's programme was an address by Dr. C. M. Stratton, of Napanee, upon the subject of Greenwich and Kew Observatories, and included many references to the history of astronomy. During the summer Dr. Stratton had visited these famous institutions, and, armed with a letter of introduction from Dr. Marsh to E. W. Maunder of the Grenwich Observatory, he had presented it and Mr. Maunder had shown him the working of the Observatory. Dr. Stratton's remarks were entertaining and helpful. On motion of Hon. J. R. Stratton and Rev. J. G. Potter hearty thanks were tendered the lecturer. Thanks were given the Board of Education for the use of the room in the Collegiate Institute for meeting purposes.

Before the meeting dispersed Mr. H. B. Collier referred to the standing invitation to any member to visit his home and make use of the telescope placed there for their benefit.

E. F.

NOTES FROM THE DOMINION OBSERVATORY

Astrophysics.—My attention has been called to the fact that the star *ι Andromedæ*, announced in the last issue of the JOURNAL as a spectroscopic binary, had previously been discovered by Mr. Barrett at the Yerkes Observatory, and announced by Professor Frost at the August meeting of the Astronomical and Astrophysical Society. Although present at the meeting I did not recall the names of the binaries announced, and the discovery here was hence entirely independent. I regret that even in this way the announcement of Mr. Barrett's discovery was forestalled. In order to enable him to make use of our measures a list of the velocities obtained from all plates measured is here appended. This list supersedes that previously published, as the wrong constants for reduction to the Sun were taken in the last three plates of the previous list, introducing an error in the values given.

ι Andromedæ.

PLATE NUMBER	DATE G.M.T.	VELOCITY
1772	August 5·87	− 6
1781	" 7·87	− 11
1832	" 26·87	+ 12
1922	October 9·76	− 36
1928	" 12·71	− 14
1939	" 19·63	+ 6
1954	November 9·58	± 0
1963	" 13·60	+ 14
1959	" 16·69	+ 29
1971	" 20·59	− 13
1977	" 21·53	+ 7
1995	December 2·55	+ 1

The star *ξ Persei* was announced by Frost and Adams in 1903 as having a high positive velocity, and although their plates showed no evidence of variable velocity, the high velocity led them to suspect that later observations might show it to be a binary. A few plates of the star, recently obtained here, have

shown the radial velocity to be undoubtedly variable; and this, I learn in a personal communication from Professor Frost, had been a long time established by them. The measures obtained here are consequently published with a view to their use at Yerkes in establishing the period. The spectrum is difficult to measure, the lines being very diffuse, and the results obtained are consequently subject to considerable uncertainty.

ξ Persei.

Plate Number	Date G.M.T.	Velocity
*1946	October 30·37	+ 120
†1953	November 6·66	+ 143
1958	" 9·77	+ 54
1964	" 13·65	− 2
1974	" 20·83	+ 45
1998	December 2·69	+ 32
1999	" 4·72	+ 51.

That the orbit of *ζ Tauri* had already been discussed by Mr. Adams was overlooked, and a few plates of the star were obtained which give velocities in agreement with those obtained by Mr. Adams. It may be of interest to mention, however, that the plates show the hydrogen lines to be probably bright, $H\beta$ undoubtedly so. The type of spectrum is quite similar to *φ Persei*, a broad emission band with a sharply defined narrow absorption centre, except that the emissive character is not so pronounced.

The new single-prism spectrograph, which has been under construction here for some time past, is now approaching completion, and it is hoped to get it into operation in the beginning of the year. In addition to its advantages over the single-prism form of the Ottawa spectrograph its completion will enable the present instrument to be used entirely with three prisms. As both instruments will have separate automatic heating arrangements, each can be kept in adjustment under constant temperature and interchanged on the telescope in a couple of minutes, thus enabling stars of every type to be most efficiently attached.

J. S. P.

* Comparison spectrum underexposed but result fairly reliable.

† Plate not of very good quality.

The Seismograph—Bosch photographic, 200 grammes—Magnification, 120.—As stated on a previous occasion there are two similar instruments mounted on the same concrete pier, the pendulum of the one pointing N–S and the other E–W. Both are provided with air damping. About a year ago the air chamber of the N–S one was removed, and oil damping substituded in the belief that more effective damping might be secured. The oil (sewing machine and watch oil mixed) was placed in a shallow pan 10 by 12 cm., and about half a centimeter deep, in which moved the vane of the pendulum. It was surprising the amount of oil or depth of immersion that was necessary to obtain the same damping coefficient as with air, 1·53. The immersion was 3 mm. Surface tension caused little or no trouble, but the advantage that was expected to be obtained in increased damping did not follow. The pan was large to minimise fluid disturbance by the relative movement of the pendulum. After removing the oil, the point against which the pendulum rests and about which it moves, was examined. It was found to be worn, which had been suspected from the inconstancy of the zero; the period of pendulum being 10 seconds. A new point was inserted, and the air chamber was replaced, being more satisfactory than oil for damping.

As usual, passing from summer towards winter, the barometric gradients increase in steepness and with them synchronize in a more or less degree the microseisms. The period of the latter is mostly between 5 s. and 5·5 s., and their maximum displacement may reach nearly 10 μ. It may be noted, that although the microseisms are closely related to steep gradients, especially when these are present to the east in the Gulf, yet the record when a wind or gale is blowing here, the resultant of steep gradients, is of quite a different type; instead of the regular "sawtooth" type, we find the oscillations irregular with a more or less sinuous movement of the zero line, that is, microseisms appear to be due more to a statical than to a dynamical effect.

When an earthquake sets in it is very undesirable to have

microseisms present, for they often mask the arrival of the first preliminary tremors, which are the most important phase to be noted. The end of the earthquake is difficult to define under any circumstance, and doubly so when microseisms prevail.

The following are the earthquakes recorded since the last notes were sent :—

November 2	N-S Component	E-W Component
		h m s
1st P. T. began	. . . . .	5 37 56 G.M.T.
2nd " "	. . . . .	. . . . .
P, P. "		5 54 20
Duration		2
Max, double amplitude	3·5 mm. at 6 43.	

Estimated distance of epicentre 6,300 km.

November 4	N-S Component	E-W Component
		h m
Waves	. . . . .	8 54 G.M.T.
Duration		0 26.

November 6	N-S Component	E-W Component
	h m s	h m s
1st P. T.	7 31 50 G.M,T.	7 31 50 G.M.T.
2nd "	7 39 08 ?	7 38 16
P. P.	7 46 30	7 46 35
Duration	1 30	3 00
Max. dbl. amp. 2·8 mm. at 8 04 12;	7 mm. at 8 02 20.	

Estimated distance of epicentre 5,900 km.

November 6	N-S Component	E-W Component
	h m s	h m s
1st P. T.	. . . . .	? 23 02 G.M.T.
P. P.	. . . . .	23 14 8
Duration		0 45
Max. dbl. amp. 2·5 mm. at 23 16 50;	4 mm. at 23 16 50.	

November 9	N-S Component	E-W Component
	h m s	h m s
1st P. T.	15 27 00 G.M.T.	15 27 00 G.M.T.
P. P.	. . . . .	? 15 44 04
Duration	. . . . .	1 30.

Epicentre probably 6,500 km.

November 11	N-S Component	E-W Component
	h m s	h m s
1st P. T.	13 39 10 G.M.T.	13 39 11 G.M.T.
P. P.	. . . . .	? 13 44 40
Duration		1 45
Max. double amplitude	1·6 mm. at 13 56	

November 12	N-S Component	E-W Component
	h m	h m
Waves	13 51 G.M.T.	13 51 G.M.T.
Dnration	1.	

November 19	N-S Component	E-W Component
		h m
Waves	. . . . .	5 46
Duration	. . . . .	40
Max. double amplitude		1·5 mm.

November 22	E-W Component
	h m s
Waves	6 45 36 G.M.T.
Long waves set in	6 55 12
" " " "	8 09 24
Duration	1 45.

November 23	N-S Component	E-W Component
	h m s	h m s
Waves	13 04 22 G.M.T.	13 04 20 G.M.T.
Duration		2
Max. double amplitude	1·5 mm. at 13 54.	

November 30	N-S Component	E-W Component
	h m s	h m s
1st P. T. ?	21 49 48 G.M.T.	21 49 48 G.M.T.
2nd "	. . . . .	. . . . .
P. P.	21 56	21 56
Duration.	1	1 40

Max. dbl. amp. 18 mm. at 27 57 30; 30 mm. at 21 59 30.

This is undoubtedly the earthquake that was felt and alarmed the natives at Skidegate, Queen Charlotte Island, British Columbia.

Terrestrial Magnetism.—During the past season the following stations of the magnetic survey, which is being made of the Dominion, were occupied: Winnipeg, Banff, Golden, Revelstoke, Sicamous, Ashcroft, Clinton, Bridge Creek, Williams Lake, Alexandria, Quesnelle, Barkerville, Spence's Bridge, Nicola, Agassiz, Vancouver, Victoria, and Departure Bay (Nanaimo). At these stations, the three magnetic elements, declination, inclination and intensity were observed.

The magnetic storm referred to by Dr. Chree in *Nature* of September 24 manifested itself very markedly in the observations in British Columbia at Williams Lake and Ashcroft, between September 4 and 12.

A well-built magnetic hut has been erected here, which will serve as a reference station hereafter. Observations will be made in it at the beginning and close of the season's work with the field instruments.

O. K.

CONSTELLATIONS ON THE MERIDIAN FOR JANUARY

Taurus is now the second sign and third constellation of the Zodiac; at a period anterior to 4000 years ago, the vernal equinox was situated in Taurus, and the year was considered to begin when the Sun was at it. The Bull, for the space of 2000 years, was the prince and leader of the celestial host. The Ram succeeded, and now the Fishes lead the year. The head of Taurus sets with the Sun at about the last of May, at which time the opposite constellation Scorpio is seen to rise in the S.E. Taurus is between Perseus and Auriga on the north, Gemini on the east, Orion and Eridanus on the south and Aries on the west, having a mean declination north 16° and right ascension IV^{h}. The constellation contains 141 visible stars, including the two remarkable clusters the Pleiades and Hyades.

Orion.—Whoever observes this constellation and learns its name will never forget it. It is too splendid to need a description. When it is on the meridian, there is then above the horizon the most magnificent view of the celestial bodies; that the sky affords and it is visible to all the habitable world, because the equatorial passes through the middle of the constellation, the three prominent stars forming the "Belt" lying almost upon this line. It is represented on celestial maps by the figure of a man in the act of assaulting the Bull, with a sword in his belt and a huge club in his right hand, and the skin of a lion in his left to serve as a shield. The nebula in the sword can be seen with the naked eye, better with an opera glass, and best, of course, with a telescope using a low power.

Lepus (the Hare) is situated directly south of Orion and comes to the meridian at the same time, on the 24th of the month.

Eridanus (the River) meanders over a large and very irregular space in the heavens. It is not easy to trace out all its windings among the stars. Its entire length is not less than 130°; which, for the sake of more easy reference, is divided into two sections, northern and southern. That part of it that lies

between Orion and Cetus (the Whale), including the greater bend about his paws, is known as the northern stream; the remainder of it is known as the southern stream.

Auriga (the Charioteer) is represented on the celestial maps by the figure of a man in a reclining posture, resting one foot on the horn of Taurus, with a goat and her kids in his left hand and a bridle in his right. It is situated N. of Taurus and Orion, between Perseus on the W. and the Lynx on the E. It is on the same meridian with Orion, and culminates at the same hour of the night, Its mean R. A. is VI^h and its Declination is 45°. Both these constellations are on the Meridian at 9 o'clock on the 24th of January. The whole number of visible stars in Auriga is 66, including one of the first magnitude and one of the second.

Camelopardus (the Giraffe) contains the stars scattered between Perseus, Auriga, the head of Ursa Major, and the Pole Star. It is situated N. of Auriga and the head of the Lynx, and occupies nearly all the space between these and the pole. It contains 58 small stars; the five largest of which are only of the 4th magnitude.

CONSTELLATIONS FOR FEBRUARY

The Lynx, like Camelopardus, exhibits no very interesting features by which it can be distinguished. It contains only a moderate number of inferior stars, scattered over a large space N. of Gemini, and between Auriga and Ursa Major. It contains 44 visible stars, including only three of the third magnitude. Its centre is on the meridian at 9 o'clock on the 23rd of February.

Gemini (the Twins).—The constellation of the Twins, is the third sign but the fourth constellation in the order of the Zodiac, and is situated south of the Lynx, between Cancer on the east and Taurus on the west. The plane of the ecliptic passes through the centre of Gemini. If the stars could be seen as the Sun appears to move amongst them, we would see it pass over the constellation Gemini between the 21st of June and the 23rd of July; but we seldom see more than a small part of any

constellation through which the Sun is then passing, because the sunlight obliterates the feeble light of the stars. Gemini contains 55 visible stars including one of the first, 2 of the second, 3 of the third, and 6 of the fourth magnitude. It is recognized by means of the two principal stars, Castor and Pollux, of the first and second magnitudes, in the heads of the twins, about 4½° apart.

Canis Minor (the Lesser Dog) is situated about midway between Canis Major and Gemini. It contains 14 visible stars, two of which are very brilliant, Procyon of the first magnitude and Gemelza of the third magnitude. The first is 23° south of Pollux in Gemini, and the second is about the same distance south of Castor.

Monoceros (the Unicorn) contains 21 small stars, seven of which are only of the fourth magnitude. It extends a considerable distance on either side of the equinoctial and its centre is on the same meridian as Procyon.

Canis Major (the Greater Dog) is situated S. and E. of Orion, and is universally known by the brilliance of its principal star Sirius, which glows in the winter hemisphere with a brilliance unequalled by any other star. The constellation contains 31 visible stars, including 1 of the first, 4 of the second and 2 of the third magnitude. Sirius is in line with the three stars in the belt of Orion, and comes on the meridian about 9 o'clock on February 11th.

A Few Variable Stars Visible During January–February

				d	h	m
o Ceti	Mag. from 1·7	to 9·5	Period	331	7	
β Persei (Algol)	" " 2·1	" 3·2	"	2	20	48·9
α Orionis	" " 1	" 1·4	"	irr.		
ζ Geminorum	" " 3·8	" 4·3	"	10	3	41
R Hydræ	" " 3·5	" 9·7	"	425	1	
α Herculis	" " 3·1	" 3·9	"	irr.		
χ Cygni	" " 7·1	" 7·9	"	1	11	57

SOME COLORED DOUBLE STARS VISIBLE DURING JANUARY AND FEBRUARY

β Cygni	Mag. = 3·2	and 5·5	Golden, Sapphire
ε Bootis	" 2·4	" 6·5	" "
α Herculis	" 4	" 5·5	Ruby, Emerald
2 *Canum Venat*	" 6	" 9	Golden, Azure
52 *Cygni*	" 4·6	" 9	Orange, Blue
ρ Orionis	" 5·1	" 9	" "
ι Persei	" 4·2	" 8·5	Yellow, Blue
η Cassiopeia	" 4·7	" 7	Golden, Purple
δ Herculis	" 3·6	" 8	White, Violet
17 *Virginis*	" 6·5	" 7	Rose.

MERIDIAN PASSAGE OF THE PRINCIPAL PLANETS DURING JANUARY AND FEBRUARY

LOCAL MEAN TIME

	For January 15				For February 15		
Mercury	1^h	8^m	p.m.		11^h	37^m	a.m.
Venus	11	20	a.m.	Scorpio, Sagittarius and Capricornus	11	3	a.m.
Mars	8	29	a.m.	Libra, Scorpio and Sagittarius	7	56	a.m.
Jupiter	3	28	p.m.	(Leo)	1	16	a.m.
Saturn	4	43	p.m.	(Pisces)	2	51	p.m.
Uranus	11	39	a.m.	(Sagittarius)	9	45	p.m.
Neptune	11	28	p.m.	(Gemini)	9	23	p.m.

JUPITER

Jupiter is in opposition on February 28, 1909. At this date the Earth is very near the planes of the orbits of the satellites and hence the apparent orbits approximate to straight lines. The eclipses and transits of the satellites during these long winter nights are very numerous, as will be seen from the list given on opposite page.

E = eclipse, O = occultation, T = transit, S = shadow, D = disappearance, R = re-appearance, I = ingress, E = egress.

JANUARY.

d	h	m		
2	3	51	I.	ED
	4	54	II.	ED
3	1	4	I.	SI
	2	10	I.	TI
	3	23	I.	SE
	4	28	I.	TE
	23	24	II.	SI
4	1	34	II.	TI
	1	41	I.	OR
	2	4	III.	ED
	2	17	II.	SE
	4	24	II.	TE
	3	27	II.	ER
	4	27	III.	OD
	22	56	I.	TE
5	23	11	II.	OR
6	0	58	IV.	TI
	4	54	IV.	TE
7	23	42	III.	TE
9	5	44	I.	ED
10	2	58	I.	SI
	3	59	I.	TI
	5	17	I.	SE
	6	17	I.	TE
11	0	13	I.	ED
	1	57	II.	SI
11	3	28	I.	OR
	3	57	II.	TI
	4	50	II.	SI
	6	2	III.	ED
	6	47	II.	TE
	22	26	I.	TI
	23	45	I.	SE
12	0	44	I.	TE
	21	55	I.	OR
13	1	36	II.	OR
14	1	7	IV.	ED
	5	26	IV.	ER
	23	33	III.	SE
	23	56	III.	TI
15	3	15	III.	TE
17	4	51	I.	SI
	5	46	I.	TI
18	2	6	I.	ED
	4	30	II.	SI
	5	15	I.	OR
	6	17	II.	TI
	23	20	I.	SI
19	0	13	I.	TI
	1	39	I.	SE
	2	31	I.	TE
	23	23	II.	ED
19	23	42	I.	OR
20	3	58	II.	OR
21	22	17	II.	TE
	23	58	III.	SI
22	3	25	III.	TI
	3	30	III.	SE
	6	44	IV.	TE
24	6	45	I.	SI
25	3	59	I.	ED
26	1	13	I.	SI
	1	59	I.	TI
	3	33	I.	SE
	4	18	I.	TE
	22	27	I.	ED
27	1	27	I.	OR
	1	59	II.	ED
	6	18	II.	OR
	22	44	I.	TE
23	21	45	II.	TI
	23	13	II.	SE
29	6	34	II.	TE
	3	56	III.	SI
30	23	22	IV.	ER
31	1	35	IV.	OD
	5	25	IV.	OD

FEBRUARY

d	h	m		
1	5	52	I.	ED
	23	46	III.	OR
2	3	7	I.	SI
	3	45	I.	TI
	5	27	I.	SE
	6	3	I.	TE
3	0	20	I.	ED
	3	12	I.	OR
	4	35	II.	ED
	9	36	I.	SI
	10	11	I.	TI
	23	55	I.	SE
4	0	29	I.	TE
	21	38	I.	OR
	22	54	II.	SI
5	0	1	II.	TI
	1	46	II.	SE
	2	50	II.	TE
6	21	45	II.	OR
8	2	40	IV.	SI
	21	54	III.	ED
9	3	6	III.	OR
	5	1	I.	SI
	5	29	I.	TI
10	2	14	I.	ED
	4	56	I.	OR
	23	30	I.	SI
	23	55	I.	TI
11	1	49	I.	SE
	2	14	I.	TE
11	20	42	I.	ED
	23	22	I.	OR
12	1	28	II.	SI
	2	16	II.	TI
	4	20	II.	SE
	5	5	II.	TE
	20	17	I.	SE
	20	40	I.	TE
	20	30	II.	ED
14	0	1	II.	OR
16	1	52	III.	ED
	6	24	III.	OR
	19	53	IV.	OR
17	4	7	I.	ED
18	1	24	I.	SI
	1	40	I.	TI
	3	43	I.	SE
	3	58	I.	TE
	22	36	I.	ED
19	1	6	I.	OR
	4	2	II.	SI
	4	30	II.	TI
	19	21	III.	SE
	19	52	I.	SI
	20	6	I.	TI
	20	9	III.	TE
	22	12	I.	SE
	22	24	I.	TE
20	19	32	I.	OR
	23	6	II.	ED
21	2	17	II.	OR
22	20	11	II.	SE
	20	26	II.	IE
23	5	50	III.	ED
24	6	1	I.	ED
	20	39	IV.	SI
	21	42	IV.	TI
25	1	1	IV.	SE
	1	26	IV.	TE
	3	16	I.	SI
	3	23	I.	TI
	5	37	I.	SE
	5	42	I.	TE
26	0	30	I.	ED
	2	49	I.	OR
	19	51	III.	SI
	20	5	III.	TI
	21	46	I.	SI
	21	50	I.	TI
	23	19	III.	SE
	23	25	III.	TE
27	0	4	I.	SE
	0	8	I.	TE
	18	58	I.	ED
	21	15	I.	OR
28	1	42	II.	ED
	4	32	II.	OR
	18	34	I.	SE
	18	34	I.	TE

AT GREENWICH MEAN NOON

JANUARY

Date 1909	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation of Time (Subtract from Mean Time)	Sidereal Time
Jan. 3	3	18h 54m 22s	S. 22° 51′ 47″	4m 30s	18h 49m 52s
6	6	19 7 33	22 32 35	5 51	19 1 42
9	9	19 20 40	22 9 24	7 8	19 13 51
12	12	19 33 42	21 42 18	8 21	19 25 21
15	15	19 46 38	21 11 25	9 28	19 37 11
18	18	19 59 29	20 36 53	10 29	19 49 0
21	21	20 12 14	19 58 49	11 24	20 0 50
24	24	20 24 52	19 17 24	12 12	20 12 40
27	27	20 37 22	18 32 47	12 53	20 24 29
30	30	20 49 45	17 45 10	13 26	20 36 19

JANUARY

		75th Meridian Time, Hours Numbering from Midnight Planetary Phenomena	Configuration of Jupiter's Satellites at 1h
	Fri. 1.	23h ☌ ☿ ♅, ☿ 1° 40′ S.	321○4
	Sat. 2.		3○124
	Sun. 3.	1h ⊕ in Perihelion.	2○14●
	Mon. 4.		21○34
	Tue. 5.		2○213
○	Wed. 6.	9h 13m Full Moon; 8h 46m ☌ ♆ ♐, ♆ 2° 33′ S.; 10h ☍ ♆ ☉.	41○23
	Thu. 7.	12h ☿ Greatest Heliocentric Lat. S.; 17h ☌ ♅ ☉.	423○1
	Fri. 8.		4321○
	Sat. 9.		43○1
	Sun. 10.		43○2●
	Mon. 11.	2h 9m ☌ ♇ ♌, ♇ 4° 11′ S.	421○3
	Tue. 12.		4○213
	Wed. 13.		1○23●
☾	Thu. 14.	13h 11m Moon's Last Quarter.	2○41
	Fri. 15.		321○4
	Sat. 16.		3○124
	Sun. 17.	19h 2m ☌ ♂ ♐, ♂ 1° 32′ S.	3○24●
	Mon. 18.		2○34
	Tue. 19.		○134●
	Wed. 20.	6h 3m, ☌ ♀ ♐, ♀ 1° 17′ N.; 20h 30m ☌ ♅ ♐, ♅ 1° 33′ N.	1○234
●	Thu. 21.	19h 12m New Moon.	2○314
	Fri. 22.	2h 46m ☌ ☿ ♑, ☿ 3° 36′ N.	3○14○
	Sat. 23.		34○12
	Sun. 24.		431○2
	Mon. 25.		2○42○3
	Tue. 26.	0h 47m ☌ ♄ ♐, ♄ 3° 1′ N.; 13h ☿ in ♒; 22h ☿ Greatest Elongation E., 18° 27′.	4○13●
	Wed. 27.		41○23
☽	Thu. 28.	10h 7m Moon's First Quarter.	42○31
	Fri. 29.	2h ♀ in ♑.	4321○
	Sat. 30.	12h ☌ ♀ ♅, ♀ 0° 21′ N.	3○12●
	Sun. 31.	3h ☿ in Perihelion.	31○24

KEY TO SYMBOLS.—☌ Conjunction; ☍ Opposition; □ Quadrature; ☊ Ascending Node; ☋ Descending Node; ☉ Sun; ☿ Mercury; ♀ Venus; ⊕ Earth; ♂ Mars; ♃ Jupiter; ♄ Saturn; ♅ Uranus; ♆ Neptune.

At Greenwich Mean Noon

FEBRUARY

Date 1909	Day of Year	The Sun's Right Ascension			The Sun's Declination			Equation of Time (Subtract from Mean Time)		Sidereal Time		
Feb. 2	33	21h	2m	1s	16°	54′	42″	13m	52s	20h	48m	9s
5	36	21	14	9	16	1	35	14	10	20	59	58
8	39	21	26	9	5	6	0	14	21	21	11	48
11	42	21	38	3	4	8	6	14	25	21	23	38
14	45	21	49	50	13	8	7	14	23	21	35	27
17	48	22	1	30	12	6	11	14	13	21	47	17
20	51	22	13	4	11	2	31	13	58	21	59	7
23	54	22	24	32	9	57	17	13	39	22	10	56
26	57	22	35	55	8	50	43	13	9	22	22	46

FEBRUARY

		75th Meridian Time, Hours Numbering from Midnight Planetary Phenomena	Configuration of Jupiter's Satellites at 1h
	Mon. 1.	21h ♅ Stationary.	2○314
	Tue. 2.	13h 54m ♂ ☿ ☾, ☿ 2° 31′ S.	2○34●
	Wed. 3.		1○234
	Thu. 4.		2|○134
○	Fri. 5.	3h 25m Full Moon.	231○4
	Sat. 6.		3○214
	Sun. 7.	5h 12m ♂ ♃ ☾, ♃ 3° 53′ S.	31○42
	Mon. 8.		24○1●
	Tue. 9.		421○3
	Wed. 10.	10h ♅ Greatest Heliocentric Lat. N.	2|4○23
	Thu. 11.	9h ♂ ☿ ☉ Inferior.	4○213
	Fri. 12.		4231○
☾	Sat. 13.	7h 47m Moon's Last Quarter; 4h ♂ in ♈.	43○21
	Sun. 14.		431○2
	Mon. 15.	15h 43m ♂ ♂ ☾, ♂ 0° 1′ N.	423○1
	Tue. 16.		21○43
	Wed. 17.	10h 1m ♂ ♅ ☾, ♅ 1° 46′ N.	○1243
	Thu. 18.	21h 10m ♂ ♀ ☾, ♀ 3° 3′ N.	○1234
	Fri. 19.	0h 34m ♂ ☿ ☾, ☿ 7° 12′ N.; 12h ♂ ♅ ♀, ♀ 4° 1′ N.	231○4
●	Sat. 20.	5h 52m New Moon.	3○14●
	Sun. 21.		31○24
	Mon. 22.	14h 28m ♂ ♄ ☾, ♄ 2° 52′ N.	23○14
	Tue. 23.	10h ♀ Stationary.	21○34
	Wed. 24.		2|○123
	Tuh. 25.		4○23●
☽	Fri. 26.	21h 49m Moon's First Quarter.	4213○
	Sat. 27.		4321○
	Sun. 28.	14h ♂ ♃ ☉.	431○2

For Jupiter's Satellites, the Circle ○ represents the disc of the Planet, ♃ signifies that the Satellite is on the disc, ● signifies that the Satellite is behind the disc or in the shadow. The configurations are for an inverting telescope.

ASTRONOMICAL NOTES.

THE PERSEID AND LEONID METEORIC SHOWERS.—I regard this as certainly the most important and interesting shower of the year. The Leonids occasionally provide a grander exhibition but the Perseids come abundantly every summer, and are not only visible all night but continue to fall during about six weeks from the second week in July to the fourth week in August. The Leonids are only to be seen on a few nights and even then cannot be observed until after 10.30 P.M., as the radiant is below the horizon in the earlier hours. Moreover it is not always pleasant watching for meteors in the cold frosty mornings of November, and in England the sky is often obscured either with cloud or fog. The Perseids come at the pleasantest season of the year, when outdoor serenading is congenial and the atmosphere frequently clear. We have yet much to learn about these great meteoric showers. We do not know the periodic time of the Perseids or whether the Leonid radiant changes its position amongst the stars from night to night.—W. F. Denning, Bristol, November 25.

PROFESSOR TURNER gives a summary of his paper on "Possible Periodic Inequalities in the Epoch of the Sun-spot Variation" in *Monthly Notices R. A. S.*, as follows: "The sun-spot maxima (and minima) occur on the average at intervals of 11·125 years. But the individual maxima (and minima) show discordances which have been tabulated for 26 periods by Wolfer. Analysing these by the periodogram method of Professor Schuster, there are indications of two periodicities, one of which the phase advances 53° per period of 11⅛ years, the other of which the phase advances only 20°. The cycles are completed in about 75 and 200 years respectively. The amplitude of each inequality is about a year, but the accidental errors are so large that either or both of these inequalities may be spurious.

"The quicker moving inequality (53°) can be brought into line with similar inequalities for the long-period variables."

PROF. CHARLES LANE POOR contributes a paper on "An Investigation of the Figure of the Sun and of Possible Variations in its Size and Shape" to the *Annals of the New York Academy of Sciences* (Vol. XVIII., No. 9). Regarding the general results of his investigations he concludes:

"1. The exact shape of the Sun is not known. The generally accepted idea that the Sun is a sphere is at least open to question. Practically every series of measures heretofore made show departures from a spherical form; but these departures are extremely minute, the difference between the different radii of the Sun being probably not more than 0″·25.

"2. A study of all the available heliometer measures shows a fluctuation in the shape of the Sun corresponding in period with the sun-spot cycle. The amplitude of this fluctuation is small, being probably not over 0″·10. This variation is shown by the great mass of heliometer measures made by the German observers in connection with the transit of Venus in 1874 and 1882, and by the superb series of observations made by Schur and Ambronn at Göttingen in 1890–1902.

"3. In addition to this long-period variation, the observations of Schur and Ambronn would seem to indicate a fluctuation in the measured value of P.–E. having a period of about twenty-eight days. The observations are so scattered that they do not permit of a thorough determination of the reality of this fluctuation and of the exact length of its period. If real, this fluctuation can be accounted for by a permanent or semi-permanent deformation of the Sun's equator.

"4. Questions as to the exact shape of the Sun, and as to possible variations in its size and shape, can only be set at rest by a long series of homogeneous observations. The data at present available are not sufficient for this purpose. Observations should be made on every clear day, and the series should be extended over at least one solar cycle.

"5. A photographic heliometer would probably furnish the best results. With such an instrument, the moments of good 'seeing' can be utilized and a number of plates taken within a short time. These plates can later be measured and reduced by the ordinary staff of a computing bureau."

SUMMARY REPORT OF THE WEATHER IN CANADA

OCTOBER, 1908.

TEMPERATURE.—During October warm weather predominated from Manitoba to the Maritime Provinces, and the mean temperature, for that portion of Canada, was from 1° to 5° above the normal. Maximal temperatures were very high, and in some parts of Ontario exceeded 80°. From Saskatchewan to British Columbia the mean temperature was subnormal, the difference from average being from 1° to 5°.

For the highest and lowest temperatures see the accompanying table.

PRECIPITATION.—Among the marked features of the October weather were the large amount of precipitation over the Western Provinces, and the continuance of severe drought from Ontario to the Maritime Provinces. With local exceptions in North Saskatchewan and Western Manitoba, the amount registered in the Western Provinces was from 36 per cent. to 200 per cent. in excess of the normal, the fall being mostly rain, but partly in the form of snow. From Ontario to the Maritime Provinces, with the exception of the Gaspé Peninsula of Quebec, and locally in Southwestern Nova Scotia, where an amount in excess of the average was recorded, the total amount of the fall was generally much less than normal, and in some districts did not reach 20 per cent. of the usual quantity.

NOVEMBER, 1908.

TEMPERATURE.—The temperature was above the average in all portions of the Dominion except in the eastern part of Nova Scotia and in Prince Edward Island, where the average was barely maintained. The positive departures were for the most part marked, varying from 6° to 9° over the greater portions of the Western Provinces and British Columbia, and from 2° to 5° in Ontario.

Temperatures for October and November

Station	October		November		Station	October		November	
	Highest	Lowest	Highest	Lowest		Highest	Lowest	Highest	Lowest
Yukon					Lakefield	79	28	61	18
Dawson	52	-22	28	-25	Lucknow	76	24	59	22
British Columbia					Meaford	77	32	63	24
Agassiz	74	30	57	32	Midland	82	30	62	25
Atlin	48	- 4	42	- 6	North Gower			68	17
Barkerville	64	6	56	0	Otonabee	75	29		
Kamloops	72	30	60	18	Ottawa	78	28	56	14
Nelson	69	29	56	19	Owen Sound	78	26	63	20
New Westminster	70	32	60	28	Paris	80	25	60	18
Victoria	67	31	63	32	Parry Sound	73	21	60	16
Western Provinces					Peterboro'	80	24	60	15
Battleford	80	12	52	-18	Point Clark				
Calgary	71	8	68	- 2	Port Arthur	74	23	50	8
Carberry					Port Burwell			60	18
Carman					Port Dover	75	27	60	10
Edmonton	71	9	62	0	Port Hope	75	24	54	19
Medicine Hat	75	14	69	- 4	Port Stanley	84	26	56	19
Minnedosa	74	17	63	- 4	Rockliffe	74	21	56	14
Moosejaw	75	16	66	-10	Sarnia	93	30	65	20
Morden					Southampton	76	29	62	25
Oak Bank					Stony Creek	85	26	64	21
Pierson	72	20			Stratford			57	14
Portage la Prairie	75	20			Toronto	78	28	64	22
Prince Albert	74	14	50	-18	Uxbridge	78	22	61	16
Qu'Appelle	74	12	58	- 8	Wallaceburg				
Regina					Welland	75	29	63	20
St. Albans					White River	70	16	46	- 6
Swift Current	75	16	62	- 6	Windsor				
Virden					*Quebec*				
Winnipeg	69	24	51	5	Brome	76	20	59	9
Ontario					Father Point	64	28	51	16
Agincourt	79	25	63	18	Montreal	75	32	56	17
Alton	85	16	58	14	Quebec	65	27	51	8
Aurora	80	21	61	13	Sherbrooke	76	21	59	12
Bancroft	79	18	55	5	*Maritime Provinces*				
Birnam	79	29	61	15	Charlottetown	66	31	52	23
Brantford	80	23	62	17	Chatham	75	28	52	20
Bruce Mines	72	21	58	13	Fredericton	77	25	55	13
Chatham	82	26			Halifax	72	27	56	25
Clinton	77	25	60	22	Hamilton, P.E.I.	68	32		
Cottam	80	26	65	15	Moncton	74	23	56	15
Copper Cliff					Parrsboro'	69	22	60	21
East Toronto					Port Hastings	5	25	5	22
Gravenhurst					St. John	68	30	54	21
Haliburton					St. Stephen	77	20	55	13
Hamilton	82	30	62	25	Summerside	68	27	58	20
Huntsville	72	21	65	15	Sussex	75	16	56	18
Kinmount	78	17	55	7	Sydney	70	30	56	26
Kingston	68	30	56	21	Yarmouth	66	26	55	29

PRECIPITATION.—The precipitation was unusually heavy over the Lower Mainland of British Columbia. It was generally a little above the average in the more northern portions of Ontario as well as very locally in Eastern Nova Scotia, but over the large remaining portion of the Dominion it was everywhere below the usual quantity and with few exceptions to a considerable amount. In the Maritime Provinces the negative departure was usually from two to nearly three inches. In Quebec and the southern portions of Ontario the deficiency was also very marked, while in the Western Provinces the precipitation varied from *nil* in parts of Southern Alberta to a half or less of the usual quantity over the larger portions of Saskatchewan and Manitoba. In the Upper Mainland of British Columbia the precipitation was locally deficient.

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